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PREFACE.

IN the Educational World old methods are fast giving place to new. History is no longer a string of Dates, or Geography the repetition of a number of names without life or meaning. That scholars learn much more readily if they feel an interest in the subject is a truism, and one great aim which the earnest Teacher always has in view is the arousing of such an interest.

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While avoiding everything that is dry, the Publishers hope to include nothing but what is educative.

To enhance the value of the Series, each book will contain Two Coloured Illustrations, and, wherever possible, a Portrait of each person whose career is set forth. In some cases Pictures or Views will be substituted for Portraits.

The whole series will be issued under the general editorship of Herbert Hayens, while every writer is, or has been, a practical teacher, thoroughly acquainted with present-day scholastic requirements.

CONTENTS.

I.—Louis Pasteur.

THE MAN WITH THE MICROSCOPE.

HAVE you ever found out anything quite new—something that nobody knew anything at all about till you discovered it? If so, you ought to be very happy, for you deserve to take a place in the ranks of the really great people of the world.

It is not at all easy to be a discoverer; it needs wide-open eyes, and a quick mind ready to pounce upon anything out of the common—besides a brave heart and a firm will.

Some people will tell you that no one has much of a chance nowadays, to find out anything new—that it was much easier in the olden times before everybody knew so much.

There is some truth in this, of course. There are few parts of the earth into which daring travellers have not sailed, or tramped, or ridden; wonderful ways of using the forces of water and wind, and steam and gas and electricity, have been thought out; men travel over the land, or

through the water, or even in the air, at a speed which would have terrified our forefathers ; rocks and oceans have been made to give up their story ; beasts and birds and insects have been studied both in their homes and in captivity ; the very heavens have been explored by the aid of mighty telescopes, the sun, moon, and stars photographed, and the substances of which they are made found out.

But there are many things yet to discover, and those who discover them will be those who have properly cultivated their powers of observation.

When we talk about discovery we usually let our minds dwell upon the work of such men as Captain Cook, Columbus, Stanley, Livingstone, Vasco da Gama, Captain Hudson, Burton and Speke, Dr. Sven Hedin, Sir Humphrey Gilbert, Anson, and a host of other daring sailors and explorers. Or we think of students of the heavens such as Galileo, Ball, Herschel, or Flammarion, spending long nights in taking observations, and long days in examining them. Sometimes our thoughts wander to inventors like Stephenson, Arkwright, Watt, Edison, Parsons, or Marconi, and we wonder at the marvellous changes brought about by their work.

Less often, perhaps, we think of those who have found out so much concerning our own

bodies, and most of us know, for instance, that Harvey discovered the circulation of the blood.

But, until very lately, few indeed would have thought of exploring the depths of a drop of dirty water, and studying for a lifetime the habits and lives of the tiny creatures who live in it. Yet this study of the very, very small has become one of the most important of all; and, by its means, knowledge has been gained which has had the greatest possible effect upon mankind.

While the astronomers with their giant telescopes have been peering into the heavens, and showing us how small our poor earth is when compared with the mighty worlds around us; while they have been mapping and naming the mountains and valleys of the moon, and the seas and canals of Mars, other discoverers have been exploring the wonders of the very, very small, watching through the microscope the growth and habits and struggles and deaths of creatures, too small to be seen with the naked eye. They have learned that many of these tiny creatures are deadly enemies of bird and beast and man, and have discovered how best their attacks may be defeated.

From the earliest times, people have devoted their lives to the study of diseases, and the cure of the sick; but it is only lately that

the true nature of many of the commonest, and some of the most dreaded diseases, has become known.

All kinds of queer ways of dealing with sick people have been practised, and in some countries are still practised. How unhappy is the lot of a sick man in Tibet, we learn from the writings of those who have entered the forbidden land. The poor fellow's skin is blistered with hot irons; he is pounded and kneaded and hustled and shouted at to frighten away the evil spirit, which is supposed to be tormenting him; and, if he manages to get well after all this rough treatment, it is not the fault of the "doctors."

Amongst some African tribes, the witch-doctor "smells" out the person whose bad mind has made the chief ill; and the poor frightened wretch is put to death without any delay.

Even in lands nearer our own, strange things were formerly done in the name of "medicine." A man suffering from the fever, which always follows loss of blood from a wound, was bled again by the surgeon to reduce the fever! The most horrible medicines were swallowed, in the hope of curing various complaints. Any general sickness, such as a great plague, was looked upon as a visitation from God;

and it was almost thought wicked by many persons to interfere with it.

Gradually, however, more and more was learned about the nature of diseases, though not always by those who had made it their life-work to attend to the sick. Some of the most wonderful, indeed, were discovered by a French student of chemistry named Louis Pasteur; and his discoveries have had such an important effect upon the treatment of many diseases, and have been of such benefit to mankind that he may well be called one of the greatest wonder-workers of modern times. His work was almost entirely concerned with the very, very small; yet it is of such interest, and its results were so astonishing, that the name of Pasteur will not be forgotten while the earth remains.

Louis Pasteur was the son of a tanner living in the Jura district of France, on the borders of Switzerland. A most interesting district this is. The heights of the Jura Mountains, with their forests of pine and beech and ash and oak, slope gradually to the plains of France. Many streams descend from the high lands, by cascade and fall and rapid, to flow at last amid the vineyards and wheat-fields of the plateau and plain. Among the mountains are extensive pasture-lands; and here large

herds of cattle and horses are fed, from June to October.

The life of the herdsmen during those few months is a very busy one. In their châlets or huts, which are big enough to shelter both themselves and the cattle, they work hard all day long, milking the cows, and making and storing butter and cheese.

The huts are long, low, heavy buildings constructed of stone, with roofs of split fir-trees, heaped with stones to keep the wind from carrying them away.

On St. Denis's Day—the 9th of October—all the animals are brought down again; for the winter in the Juras begins early, and is more boisterous than any winter in our country. The herdsmen tie their clothes in a bundle, and hang the bundles between the horns of their favourite cows; and then all come down together.

In a district like this a great deal of leather is prepared from the hides of the cattle; so that there was plenty of work for Louis' father.

Young Louis' education was the best his father could command for him, and was intended to fit him for the post of professor, at one of the schools or colleges of France. The finishing studies were obtained at the Normal School of Paris; and it was while attending the lectures at that school that Louis' mind was turned to what was

to be his life-work, the study of the very, very small, by means of the microscope.

He began by examining crystals, finding out new truths concerning them, astonishing the most learned men of the time, and delighting the friends who believed he had a great future before him.

At this time he was a grave and quiet young man, almost shy in the presence of strangers, and so entirely devoted to study that his father, who was afraid he would injure his health, asked another student to look after him, and insist upon his taking a reasonable amount of outdoor exercise.

In such research, and in teaching at the various colleges to which he was appointed, Pasteur spent the years between twenty and thirty; but it was not until he was made professor at the new school of science at Lille that he turned his attention to the particular studies which were to make him famous.

The country round about Lille is very different from the department of the Jura, where he had been born. The town stands in a fertile and level country, in the extreme north of France, close to the Belgian frontier, and only sixty-seyen miles south-east from Calais. It is a strongly-fortified walled town, noted for its manufacture of linens, cottons, woollens, velvets, and ribbons.

Chemical works, soap and tobacco factories, and dye-works employ hundreds of people; and, from the beet, quantities of which are raised in the fertile fields around, thousands of tons of beet-sugar are made. From this sugar is manufactured a great deal of spirit, or alcohol.

The history of the town makes interesting reading. It has belonged at different times to the counts of Flanders, the kings of France, and the dukes of Burgundy. Marlborough took it in 1708; but in 1792 it stood out against the Austrians, who failed to capture it.

Railways and canals connect Lille with all parts of France and Belgium.

In the summer of 1856, when thirty-four years of age, Pasteur was asked by one of the manufacturers of beetroot alcohol, if he could tell the cause of the poor quality of the spirit that was being produced, and if he could find any way of improving it.

Here was a problem after Pasteur's own heart, and every day he spent some time at the factory, taking home with him specimens of liquors and ferments, for examination under the microscope. He soon found that the globules of healthy fermentation were of a different shape from those of unhealthy fermentation, and that at a certain time they began to turn the liquor sour.

Pasteur showed how, by using a microscope, the manufacturers could tell at once when the fermentation was turning unhealthy, and thus they were able to avoid the failures which had so distressed them. This sounds very simple; but no one had ever before thought of such a way, and it saved the manufacturers many thousands of francs.

Following up his inquiries into the nature of ferments, examining amongst others the ferment that turns milk sour, Pasteur discovered the remarkable truth that all ferments are caused by different kinds of yeast, and that the globules of these yeasts grow and bud and multiply in the liquor. But how did the spores of these yeasts get into the various liquors? Where did they come from?

There were only two possible sources—they must either be already in the air, ready to drop into the liquor, or they must be produced in the liquor itself. All who had examined the question were sure that the ferment began from nothing, and in the liquor itself, but Pasteur could not accept such an opinion. He believed that the spores from which the ferment grew had been thrown off from other fermenting liquors, and had been floating in the air, ready to sow themselves in any suitable substance which might offer.

So, you see, the examination of crystals had given place to the examination of ferments and their spores; and already the followers of one great industry had occasion to bless the name of Pasteur.

High honours were conferred by the French Academy of Sciences upon this man who "read Nature by dint of patience." Many eminent men warned him, in a friendly way, not to plunge too deeply into this difficult question of the beginnings of things; but he told them he could not stop where he was—he must go farther.

From the earliest times, men had believed that life could begin, under favourable circumstances, where no life had ever before been. The thinkers and poets among the Greeks and Romans of old time firmly believed that such a thing could happen; and, in the sixteenth century, a man of science gave a recipe for the creation of mice. This was it:—Put some dirty linen into a box or basket, together with a few grains of wheat or a piece of cheese!

Some years after this an Italian said that a certain kind of timber, after rotting in the sea, produced worms which became, first butterflies, and then birds!

Many people believed that the worms or maggots found in rotten meat began life there;

to: Pierre Petit, Paris.
W.W.

Louis Pasteur.

but an Italian named Redi put a piece of wire gauze over some meat, so that the flies, attracted by the smell, could not settle on it. The flies laid their eggs on the gauze, and from those eggs were hatched the maggots, which had until then been believed to begin their life in the meat from nothing.

Other experiments of the same kind seemed to show still further the impossibility of any living thing coming into life from nothing at all; but, when the microscope was invented, and showed millions of tiny creatures living in a single drop of rain-water, and swarming in any kind of soup which had been exposed for a few hours to the air, people began again to believe that all these living forms must begin life from nothing, in the place where they were found.

The argument went on year after year right up to Pasteur's time. He had been led to look into the matter by his work on ferments; and his first thought was, "If the germs or beginnings of these little creatures or plants are in the air, is it not possible to trap some of them?"

Acting on this idea, he made an instrument, by means of which a current of air could be drawn through a plug of cotton-wool. The cotton-wool soon became black with specks of

dust, left by the air as it passed through; and in this dust the microscope showed countless spores and germs of many kinds.

His next step was to get some liquid which would readily go bad—such, for example, as a drop of blood, a little thin meat soup, or a small quantity of milk—and protect it in such a way that the particles of dust could not fall into it. He found that, protected in this way, the liquids would remain good for a length of time; but, if he put into one of them only a fragment of the dusty cotton-wool, a change took place at once.

He even used for the cotton-wool a plug of asbestos fibre, thinking that perhaps the cotton-wool might have something to do with it; but the results were the same. He now felt sure that the germs or spores caught in the plug caused the change in the liquor.

Many eminent men thought quite the opposite; and they and Pasteur spent much money and time in a long series of experiments, even climbing mountains to get the purest and cleanest air possible. Public opinion was against Pasteur, but he felt more and more sure that he was right. He even began to wonder if the beginnings of some diseases were not to be found in these tiny germs, floating on the particles of dust in the air.

He now went back to his studies upon fermentation, and, to his great delight, discovered the ferment which caused butter to turn rancid. He also found that some of these tiny living things could exist deep down in the liquor, entirely without air.

Another valuable discovery which he made —he was now about thirty-nine years of age— was that the work of turning wine into vinegar was performed by a tiny fungus, which had the power of taking oxygen from the air, fixing it upon the alcohol in the wine, and so turning it into acid. This upset all previous ideas as to the formation of vinegar from wine.

This discovery was followed by a careful examination into the causes of the diseases of wines. An Englishman had written to him some time before: "People are astonished in France that the sale of French wines should not have become more extended here since the Commercial Treaties. The reason is simple enough. At first we eagerly welcomed those wines, but we soon had the sad experience that there was too much loss occasioned by the diseases to which they are subject."

Pasteur wondered if the diseases, which occurred after the wine was ready for export, were caused by ferments, too small to be seen

without the aid of the microscope, minute forms of vegetation, the germs of which, after settling on the surface of the wine, would develop under favourable conditions, and make the wine acid, or bitter, or "ropy."

His native department of the Jura is one of the largest wine-producing areas in France, as much as ten million gallons being sometimes obtained from one year's crop of grapes. The district round the town of Arbois, where Pasteur's father lived, is famed for its rich tawny and rosy wines; and, on hearing that Pasteur intended to inquire into the cause of the acidity which so often ruined their year's product, the people of the town offered to find him a laboratory during his holidays, and to pay all expenses.

Pasteur, however, was too modest to accept such an offer, fearing that his discoveries might not be important enough to be worth all the money which would be needed. He got a tinker of the place to make him all the apparatus he would require, and then had it set up in an old coffee-room.

His task was to find some way of preventing the development of the ferments; and, after many experiments, he found that he needed only to heat the wine to a certain point, and keep it for a few moments at that temperature.

This would kill all the germs; and the wine would keep perfectly.

Another very simple process, you see—but nobody had ever thought of it before. Now that it was discovered, people simply laughed at such a remedy, and refused to use it!

While Pasteur was trying to convince them that his way was the right one, and that if they would follow it they might extend their trade in wine, as it had never been extended in the history of France, he was suddenly asked by Dumas, his former master of chemistry in the Normal School of Paris, to undertake a very difficult task. This was to find out the cause of the silkworm disease which, beginning in France, had spread through all the silk-producing countries but Japan, and threatened to ruin the whole industry.

The history of the manufacture of silk is a very interesting one. Like many other wonderful discoveries, such as printing, the manufacture of gunpowder, the making of paper, and the use of tea, it hails from ancient China.

About two thousand six hundred years before the birth of Christ, the wife of the Emperor Hwang-ti found that the caterpillars of a certain large moth spun round them a cocoon, from which might be unwound a thread of great length, but of the utmost fineness and strength.

These threads, when spun and woven into a fabric, gave to the world that China silk which was so highly prized.

The people of Japan and of Korea found out the secret some centuries before the birth of Christ, but it was not brought to Europe till about five hundred and fifty years after the beginning of the Christian era.

Even then, it was only the daring of two Christian monks which gave the secret to Europe. These two brave men journeyed into China, to find out how the wonderful fibre was produced, and brought back some of the eggs of the silk-worm moth hidden in a hollow cane.

These were hatched in Constantinople, and it was there that the European silk industry had its beginning. It was found needful to cultivate the white mulberry-tree; for, though the caterpillar or "worm" will feed upon other trees and plants, the silk produced is not so fine as when the caterpillar is allowed to feed entirely upon the mulberry.

From Constantinople the industry spread amongst the Greeks, Corinth becoming one of the chief centres. During the twelfth century, the King of Sicily took prisoners a large number of Grecian silk-workers, and carried them off to Palermo. Here they set up their looms, and, in a short time, the towns of Italy were

engaged in the trade, the silk of Venice, Florence, and Milan becoming famed for its excellence.

From China, in the meantime, the art of silk-weaving had been carried into the heart of Asia—it is said by a princess, who was obliged to flee from her father's anger, through marrying a lowly lover. Through Khotan it reached Persia; and, either from the Persians, or from the Sicilians, the Moors became acquainted with it, and introduced it into Spain.

About the middle of the fifteenth century it took root in France, though it did not become a success for nearly a hundred years. At last, however, the excellence of French silk caused it to be very highly valued in England, and a large quantity was imported.

James I. was anxious to introduce the cultivation of the silkworm, and the manufacture of silk into England and Virginia; but his efforts were not successful. Many years afterwards, however, the industry did become most flourishing in England, the raw silk being imported from China, Japan, and Egypt.

But the beautiful city of Lyons, situated on the Rhone in the south of France, became, and still remains, the chief silk-manufacturing centre of the world, the skill of the French

workmen in matters of design being far above that of any of their rivals.

At the height of its prosperity, however, there came a misfortune which threatened to ruin the whole industry. A disease broke out among the silkworms, and made the cocoons valueless. This disease, which was called pebrine or the pepper disease, because the insects suffering from it looked as if they had been sprinkled with pepper, began in France, but quickly spread across Europe into India, Persia, and China, until Japan alone could supply healthy eggs, or "seed," as it was called.

The silkworms attacked by this disease were almost sure to die. Even if they lived and became moths, their eggs produced caterpillars which generally died before spinning.

What this disease meant to France can be understood, when the fact is mentioned that the money made from silk-culture dropped from one hundred and thirty million francs in 1853, to thirty million francs in 1865.

It was this disease for which Dumas asked Pasteur to find a remedy.

"I attach the greatest importance," Dumas wrote, "to seeing your attention fixed on the question which interests my poor country; the distress is beyond anything you can imagine."

"Your proposal," answered Pasteur, "throws me into great perplexity; it is indeed most flattering and the object is a high one; but it troubles me. Remember, if you please, that I have never even touched a silkworm."

His love of his country, however, and the deep affection he felt for his old teacher, made it impossible for Pasteur to refuse to undertake the work.

His first question was, "What causes those little black spots upon the insects?"

Going down to Alais, a little town where much raw and dressed silk was produced, he questioned the cultivators. He learnt that they had employed all sorts of queer remedies, such as sprinkling the silkworms with sulphur, soot, ashes, mustard, sugar, and even quinine. Some washed the mulberry-leaves with wine or rum—some smoked the caterpillars with chlorine gas, or the fumes of coal-tar. But it was all of no use—the disease spread more and more.

"A traveller coming back to the Cevennes after an absence of fifteen years," Pasteur wrote, "would be saddened to see the change in the countryside. Formerly he might have seen robust men breaking up the rock to build terraces, against the side, and up to the summit of each mountain; then planting mulberry-trees on these terraces. These men, in spite of their

hard work, were then bright and happy, for ease and contentment reigned in their homes.

"Now the mulberry plantations are abandoned, the 'golden tree' no longer enriches the country, faces once beaming with health and good humour are now drawn and sad. Distress and hunger have succeeded to comfort and happiness."

His first discovery was that the disease did not begin in either the egg or the caterpillar, but in the moth.

"If only healthy moths can be procured," he wrote, "the health of both eggs and 'worms' is assured."

Hundreds of moths were examined by him under the microscope; but nearly all were diseased. He managed, however, to find two or three couples quite healthy; and he was presented with four more.

These moths having laid their eggs and died, he was obliged to wait until the next spring, to see whether his idea was the right one—whether these eggs of healthy moths would hatch into healthy silkworms.

During this same year, Pasteur tried to find the cause of that dread disease cholera, which, arising in Egypt, had travelled to Paris, and was claiming, during the month of October, more than two hundred victims a day.

One of his friends warned him of the terrible danger he was running, of himself dying of the disease.

"Studies of that sort," he ended, "require much courage."

"What about duty?" asked Pasteur simply.

His splendid work was beginning to attract the attention of the highest in the land, the Emperor and Empress themselves showing the keenest interest in it, inviting him to stay with them, and to explain to them some of his discoveries.

In the midst of all this success, Pasteur was passing through one of the most sorrowful periods of his own life—his father and two of his little daughters all died within the year.

"I am now wholly wrapped up in my studies," he wrote to a friend. "They alone can take my thoughts from my deep sorrow."

Now followed a time of hard work—so hard, indeed, that his wife became very anxious about his health. He was now certain that he was on the right track; but had again to wait a year, before the hatching of his new broods would bring proof that could not be denied.

"The year 1867," he said, "must be the last to hear the complaints of silkworm cultivators."

In the meantime, his plan for securing that

wines should keep without risk of disease had been adopted by many persons. Raising the temperature of the wine in the way he advised was called "pasteurisation" after himself; and in 1867 he was awarded the Grand Prize Medal of the Paris Exhibition.

He was now so sure that his method of detecting the beginnings of the disease in silk-worms was right, that he advised the people at Alais to provide microscopes for the examination of the moths.

His plan was quite simple, as usual. Each female moth was to be laid on a small square of linen to lay its eggs. Then the moth was to be pinned up in a corner of the same square, where it gradually dried up. Later on in the year, the withered moth was to be moistened in a little water, pounded in a mortar, and the paste examined under a microscope. If the slightest trace of the pepper-like specks was observed, the linen was to be burnt—eggs and all; only eggs from moths free from disease were to be kept, and allowed to hatch.

Now, this method was a most unpopular one, with those who made their living by importing eggs, or "seed," as it was called; and they employed all kinds of means to throw discredit upon Pasteur, and to coax people into buying their stock. Most of the broods

hatched from these eggs were unhealthy, and much loss was caused to those persons who bought them.

But all this work upon silkworm culture had not entirely taken away his thoughts from his study of ferments; and he was invited by the Mayor, and the President of the Chamber of Commerce of Orleans, to come to their city and give a public lecture on the results of his studies on vinegar.

Orleans is one of the oldest cities in western Europe. Long before the time of the Romans, a town was built there, on the right bank of the Loire—a town afterwards plundered and burnt by Julius Cæsar. The Romans rebuilt it, calling it Aurelianis after the Emperor Aurelian. Attila, king of the Huns—"the scourge of God"—as he was called by the terror-stricken Romans, was defeated under its walls in the year 451. Afterwards it was taken by the Franks, and was made the capital of Burgundy. The Normans took it in the ninth century; and under the early kings of France it was a place of importance.

You will all remember that it was besieged by the English in 1428, and relieved by the heroic maid, Joan of Arc. The city suffered much during the religious wars of the sixteenth century, and also in the terrible Franco-Prussian

War, of which you will hear later. It was here that the French gained their only victory during the entire war.

The city is pleasantly placed on a wide plain sloping to the river, and the cathedral is one of the finest churches in France. Orleans is a busy place, the centre of a large trade, especially in the wine, brandy, and vinegar produced in the country about it.

Wine left exposed to the air becomes vinegar; but, if it is left exposed too long, the quality of the vinegar becomes worse and worse. Pasteur showed that this change is brought about by the presence of a very, very small plant, or fungus, the spores of which float in the air, and drop into the wine. This little plant had, he said, the power of taking from the air oxygen gas, which turned the alcohol in the wine into acetic acid or vinegar.

But if this process went on, the acid itself was broken up into carbonic acid and water, and the vinegar spoilt. Pasteur showed that, by heating the vinegar, the fungus could be killed; and if the vinegar was then kept from contact with air, its quality would remain unaltered.

Pasteur also showed the vinegar-makers how to avoid many of the errors which had hitherto caused them heavy loss.

In the spring of the next year he went again

to Alais, and found to his joy that the silkworm-cultivators who had followed his advice had met with complete success.

Some experiments, carried out to test the truth of his idea about the keeping of wines, were completed about this time, proving to the satisfaction of everybody, save a few of those people who never will be satisfied, that, if the wines were "Pasteurised," they would keep for almost any length of time.

But few men can work as Pasteur had worked, from early morning till late in the evening, day after day and week after week, without injury to their health; and his hard toil brought on an illness—paralysis—from which he was long in recovering. As soon as he could be moved, he had himself taken to Alais, to watch the result of his silkworm experiments.

Gradually his plan was admitted to be the only one which could deal with the silkworm disease, and, by following it, the industry was once more made prosperous.

All this time, Pasteur's mind had been grappling with a problem, more vast and of even greater importance, than any hitherto mentioned. His desire was to learn all he could about the tiny germs, upon which he thought many putrid diseases depended.

His researches into the cause of gangrene, or

the poisoning instead of healing of wounds, drew the attention of the English physician, Sir Joseph Lister, and led to his discovery of the antiseptic treatment of wounds, that is, washing them with a preparation which kills all harmful germs, and binding them with bandages soaked in a similar preparation.

By means of this treatment, which has been adopted in all hospitals, thousands of lives have been saved.

France was now entering upon the most terrible time in her history. The Prussian nation, gradually growing stronger, had begun a career of conquest which was to result in the formation of the present German Empire. Austria and Denmark had been attacked and defeated, and large slices of territory taken from them. Now, in 1870, war broke out with France, and an army of over half a million German soldiers swarmed into the country, under three great leaders, the Emperor William, Bismarck, and Von Moltke. The French, who had only half the force and were quite unprepared, were defeated at every point, and driven before the victorious Germans into the city of Paris, and there besieged.

The distress and misery of the French people, during this time of invasion and defeat, is terrible even now to read about. Worst of all,

M.W.W. Count Ferdinand de Lesseps. E

they were badly led, and could not trust their leaders. The Emperor Napoleon III. was taken prisoner with his whole army at Sedan ; and in Paris people were reduced to eating dogs and rats and mice.

Pasteur, crippled though he still was from his illness, could hardly be kept from taking a musket on his shoulder, and giving his life for his beloved country; his son was among the first volunteers.

Great as was the number of men killed in battle, during this terrible war, the number who died afterwards by the festering of their wounds was even greater. Hundreds and thousands of wounded, who would nowadays recover, died on the eighth or tenth day, of diseases which now can be prevented.

Becoming anxious about his son, Pasteur, with his wife and daughter, set out to seek him amongst the broken army retreating towards Switzerland.

As they went along in their old carriage—the only one obtainable—they found the roads full of miserable, half-starved soldiers in tattered uniforms, begging for bread as they marched along in the snow, under the cold, gray sky of winter.

After travelling for four wretched days, they came to Pontarlier. The town was full of

soldiers, some lying in the church, and some crouching round fires in the streets; some trying to bandage their frozen feet, and some begging for food, or for straw to lie upon.

Near the gate they met him for whom they were seeking—a gaunt soldier wrapped in his greatcoat, and helping himself painfully along by clinging to the edge of a cart.

So full of pity and sorrow for poor France were all their hearts that they could utter no word of greeting.

The war ended with the surrender of Paris to the German army towards the end of January, 1871. For four months the city had held out, at first against hunger, and then against bombardment and hunger together, while armies of Frenchmen from the west, from the north, and from the south-west tried bravely, but in vain, to raise the siege.

The taking of their beautiful city was to Frenchmen the worst thing that could have happened to the nation—even yet a true French patriot can hardly speak of it without quivering lips. So deeply did Pasteur feel, that he sent back to the University of Bonn the diploma they had conferred upon him.

One rather comical outcome of Pasteur's anger against the Germans was his resolve to show French brewers how to brew better beer than

the Germans. In order to study his subject, he came over to England, and examined both beer and yeast at one of the most important London breweries, telling the managers many things which they had not known about their own beer. So impressed were they that they lost no time in buying a powerful microscope with which to examine all their yeasts, and thus prevent the heavy losses which had occurred through beer going bad.

From London Pasteur went to Paris, still making experiments upon beers and yeasts His final conclusion was that all changes in beer are caused by germs, or ferments, that these ferments are brought by the air, and that they can be destroyed and the beer kept good for almost any length of time, by raising it to a certain temperature for a few moments. Beer treated in this way is known as "pasteurised" beer.

But Pasteur's mind was still dwelling upon how to discover and destroy the causes of those diseases, which have been called the "scourges of mankind." Surgeons, both in France and in all other civilised states, had by this time adopted Lister's treatment of wounds —though too late for the poor men wounded in the late war; but terrible diseases yet remained to be cured.

Among these was anthrax, a disease from which, every year in France alone, thousands of sheep, cattle, and horses died. Animals smitten with this dread fever almost always died in a few hours; sheep would linger behind the flock, with hanging head and shaking limbs and gasping breath, dying sometimes before the shepherd was aware they were ill.

In Russia, fifty-six thousand cattle, besides thousands of sheep and horses, and over five hundred people, died of this disease in the three years before 1870.

Several doctors had examined the bodies of animals which had died from anthrax, and some believed that the blood of these victims contained germs of the disease; others laughed at the idea.

Dr. Koch, the German doctor, managed to cultivate some of these little rod-like germs, and to prove that rabbits and guinea-pigs could be made to take the disease by injecting a little of the fluid, containing these germs, under their skin.

Pasteur not only proved that these germs, or "microbes," as they were now called, caused the disease, but he proved that birds, whose blood is much warmer than that of animals, could not take the disease, except when the temperature of their blood was lowered, by putting them for some time in a cold bath.

He even proved that a hen treated in this way, and already suffering from the disease, would recover, if taken out of the bath and wrapped up warmly.

But, though the farmers' poultry was thus shown to be in no danger from anthrax, the loss caused by the death of domestic animals was enormous. In one district alone, the annual loss was nearly a million pounds. Pasteur was able to convince the people of this district—the Beauce, as it used to be called, between the Seine and the Loire—that grass, growing upon the ground where animals dying from the disease had been buried even years before, could give anthrax to animals feeding upon it.

At this time he began to look into the causes of chicken-cholera, from which thousands of poultry died every year. While considering this disease, and examining the germs which produced it, he stumbled upon the greatest discovery of his life.

He had been making what are called "cultures" of the germs of the disease—sowing the germs, that is to say, in fluids which favoured their increase—and then treating with these cultures other chickens in order to observe the effect. On one occasion, he used an old culture, which had been put aside and forgotten. To his surprise, the poultry treated with this

old culture took the disease very slightly, and quickly recovered. Treating them with a culture freshly prepared, he was amazed to find that even this had now not much power upon them, though it was fatal to birds not already inoculated with the old culture.

Pasteur's quick mind saw that here was the means of defeating the chickens' deadly enemy. By treating them first with very old cultures, then with fresher and fresher ones, he found that at last no culture had any effect upon them—they could not take the disease, or only in a very mild form.

He now felt sure that he had found out a way of protecting animals from anthrax; and by experiments upon numbers of sheep and cattle, he proved that by treating them as he had treated the chickens, all domestic animals could be rendered safe.

This all seems simple enough now, but it took Pasteur many, many weeks of ceaseless labour, to find out how to obtain a culture of anthrax germs, which would answer his purpose. For one thing he found that he had to keep it at a temperature higher than blood-heat, by about ten degrees.

Following this discovery, for which owners of sheep and cattle all over the world have reason to be grateful, Pasteur tackled a still

more dreadful disease, hydrophobia, the disease which attacks those bitten by mad dogs, and which until that time had always ended in a most terrible and painful death.

It must not be thought that Pasteur's wonderful discoveries were received with pleasure by every one. Time after time he was called upon either to prove the truth of his statements, or to defend himself from angry rivals, who seemed willing to do anything to throw discredit upon him.

In his experiments, he had been obliged to inflict pain and disease and often death upon animals, and many good people tried in every way to prevent these experiments from being carried out.

This was so while he was trying to find a remedy for hydrophobia. He discovered that the disease was one belonging to the nerves and brain; and, in order to obtain a culture of the germ, he had to inoculate the brain itself of many dogs and rabbits. It was not till he had saved the lives of many people, who otherwise must have died a horrible death, that tender-hearted persons ceased to regard his experiments with horror.

Pasteur's object was always to obtain a culture of the microbes of the disease, so weakened in their power that they would set up only a mild form of the disease. This

culture is then called a "vaccine"; and Pasteur said that an animal or a person treated with it would be protected to a great extent from the disease itself.

Having obtained his vaccine against hydrophobia or rabies, he treated many dogs with it; and they were found to be protected from any attack of the disease, even though they might be bitten by mad dogs.

His next discovery was a very important one. He found that if two dogs were taken, both of which had been bitten by a mad dog, and if one only of them was treated with the vaccine, that dog showed no sign of rabies, while the other died from it.

Still he did not like to try his remedy upon man, fearing that, if it did not act, he might be blamed for the death of the patient.

On July 6, 1885, however, a little Alsatian boy was brought to him with no fewer than fourteen bites from a mad dog upon his body. Pasteur hesitated no longer, though during his treatment of the boy he passed sleepless nights, in which his anxiety was almost too great to be borne.

The boy was treated twelve times in ten days. Then followed an anxious time of waiting — for hydrophobia is slow in showing itself. As week after week passed, and the boy remained in perfect health, Pasteur was at last

convinced that he had conquered another terrible foe of mankind.

As soon as the news of this wonderful cure was given out to the world, people bitten by rabid dogs began to arrive from all parts to Pasteur's laboratory, and in all the cases where there had not been too great delay, they were cured. People came from Germany, from Britain, Russia, and even America, and went back rejoicing.

From all the nations came subscriptions towards the building and fitting up of a "Pasteur Institute," over which Pasteur himself should preside; people of all ranks sent sums of money, large and small, to help in this work.

During his long life Pasteur had received many proofs of the esteem in which he was held, by people of many nations. When he attended the Medical Congress held in London in the year 1881, he was greeted with such an outburst of cheering that he himself thought it intended for the Prince of Wales. After the meeting he was presented to the Prince of Wales, and to the German Crown Prince.

In 1884 he went to Edinburgh as one of the French delegates, on the occasion of the three-hundredth anniversary of the founding of the University, and met with quite an ovation.

Every honour his native country could bestow was given to him, and no citizen ever deserved

them more. In a public lecture given to the London Royal Society, Professor Huxley, one of Britain's leading men of science, said:

"Pasteur's discoveries alone are of sufficient value to France, to pay the whole of the money demanded by Germany after the war of 1870."

In uttering these words he was thinking of Pasteur's discoveries concerning the manufacture of wines and beer, and their safe keeping, and the manufacture of vinegar; the bringing back prosperity to the silk industry; the safety of cattle and sheep from the diseases which had caused such loss to farmers; the disappearance from hospitals of the fatal diseases which used to follow wounds and operations; the prevention of swine-fever and chicken-cholera; and last, but perhaps greatest of all, the protection from hydrophobia of people bitten by mad dogs.

Even with Pasteur's death, which occurred in 1895, when he was seventy-three years of age, the work which he had begun did not finish. The young men whom he had trained, and clever doctors all over the world, fired by his example and following his methods, have conquered one disease after another; so that the whole world, and not France alone, is to-day deeply indebted to Louis Pasteur, one of the noblest sons of France, and a patriot in the deepest and truest sense of that often misused word.

II.—Count Ferdinand de Lesseps.

ONE of the first results of civilisation is the breaking down of the barriers of suspicion, which separate savage peoples. When the folk of one village are in a state of continual warfare with the folk of the neighbouring villages, it is to their interest to make the approach to their homes as difficult as possible; and they look upon every stranger or traveller as at least a possible enemy.

Their few wants they themselves are able to supply; and their dealings with their neighbours are marked by the utmost distrust.

As their tastes become more refined their wants become more numerous. Food and clothing and shelter are no longer enough; they begin to dress and decorate their bodies, to long for greater choice of food than the forest or plain around them can supply, and to hoard up a store of wealth in ornaments, domestic cattle, or grain and other food-stuffs.

Barter with the people of the villages around, extends to people living at greater distances

from them; and this in time leads to the discovery of the usefulness of having certain coins, or tokens, made of the rarer metals, the value of which is settled by custom, and with which the business of exchange can be carried out with much less trouble.

The increased trade in things brought from distant parts of the country compels the making of roads, unless there should happen to be numerous streams deep enough, and slow enough, to enable the traders to take their goods from place to place by water.

As civilisation advances, and people come more and more into contact with one another, their suspicion and dislike gradually die out; and with a greater feeling of friendliness villages are linked together by beaten paths, or even by well-made roads.

This work of bringing closer together, as it were, widely separated portions of the same country, is also found to be very useful by a conquering army. When the Roman legions conquered Britain, they soon found it impossible to convey men, baggage, and food quickly enough through the marshy or forest-covered country, to districts where rebellion had broken out, or into which the fierce mountaineers of the north and west were making inroads. For this reason they set to work to make the splendid

paved ways, several of which are even now in use.

But the making of roads is costly, and even when they are well made, as were the roads of the Romans, their upkeep is a heavy tax upon those who use them.

As soon as men advanced beyond the making of coracles, or basket-work boats covered with skins, and discovered how to construct a canoe or boat, they began to make more use of rivers and streams, for the transport of themselves and their goods. Here was a kind of road which needed no repairing, and, though the current was against them in one direction, it helped them very much in the other.

Again, even when they had to paddle or pull upstream, the work was not so hard, or so painful, as was the carrying of the goods upon their backs, and not nearly so expensive as the employment of beasts of burden.

The two serious drawbacks to this method of transporting goods were the twisting and winding of the stream, which made the journey so much longer, and the presence of rapids and waterfalls, round which both boat and goods had to be carried.

It was not long before some of them thought the journey might be made shorter, and the rapids avoided, by digging out a new channel,

into which part of the water of the river might be turned.

There is little doubt that canals had been made in very early times, for the purpose of watering lands at a distance from the streams. Such canals were made in Egypt, China, and Peru; and they are still of great service in many countries.

The first canal in Europe is said to have been made by Xerxes, the famous Persian monarch. He was advancing from Asia, with a mighty army and fleet to conquer Greece; and he had a canal cut across the low isthmus of Athos, in order to get his fleet quickly and safely into the Ægean Sea.

The Romans were famous canal-makers as well as road-makers. Traces of the canals they made are still to be found in Italy, Holland, and Britain.

Long before the time of the Romans, however, the Egyptians had made splendid canals, one of which connected the Red Sea with the river Nile, and so with the Mediterranean Sea.

It was not long before people saw that if rivers could be joined in this way, there was no reason why big towns at a distance from each other should not be connected by canals.

The Chinese carried out these works on the grandest scale, as they did also in the building

of walls and of bridges. The Grand Canal, which was begun thirteen hundred years ago, and took six hundred years to finish, was nearly one thousand miles long. It connected the towns of Peking and Canton; and at the present day thousands of barges float on its waters, carrying every year thousands of tons of goods, and millions of passengers.

Since canals pass through large tracts of country, the surface of which is at various heights above sea-level, they have to be made in water-tight sections, to prevent all the water running out of the higher sections into the lower. The problem of getting the boats or barges from one section into another, without allowing the water to escape, was a very difficult one to the early canal-makers. Just try to think for a moment how you would manage it, and you will find the task by no means an easy one.

The Chinese solved the puzzle in this manner. At the end of each section was a double inclined plane, the one slope leading out of one section, and the other leading into the next section. At the head of the slopes, where the two planes met, was a powerful windlass or capstan. A rope was fastened to this, and to the bow of the boat; bars were placed in the holes in the head of the capstan, and the boat

was hauled up the slope, as an anchor used to be raised, the men tramping round the capstan. In the same way, if needed, it was lowered into the next section.

Clever as the Chinaman has often shown himself, in works needing great engineering skill, his talent has always had the strange feature of going so far, and then coming, as it were, to a full stop. It is doubtful if the Chinese canal-makers would ever have hit upon the plan invented by European engineers, for passing a boat from one section of a canal to another at a different level, without losing all the water.

Whether Dutch or Italian engineers should have the credit is not quite certain, though the weight of evidence seems to be in favour of the Italians, who, for many centuries, were far ahead of the rest of Europe in all the arts and crafts.

Early in the fourteenth century, canals were made with what are called "locks" between the different levels—a greatly superior method to the Chinese inclined planes.

Some of you may have seen a lock; but a brief explanation of their manner of working may be helpful.

At the end of each section is a water-tight compartment, formed usually of solid masonry,

and big enough to contain the largest boat or barge using the canal.

Each end of this compartment is closed by heavy swinging gates, which open against the current. These gates are so made that they meet before they are in a straight line, in order that the pressure of the stream against them may make them close so perfectly that no water can escape.

Near the bottom of the gates are holes or sluices, as they are called, closed by sliding doors worked from above.

Let us suppose that a barge is about to pass from a lower to a higher level. As she approaches the double gates, the sluices are opened, and the water pours out, till the level in the lock is the same as that of the section upon which the barge is floating. Then the gates are opened, and the barge at once enters the lock.

As soon as she is comfortably moored inside, the gates are closed behind her, and the sluices shut down. Before her is the second gate, still closed, and shutting her off from the higher section.

As soon as the gates behind her are closed, the sluices in the gate before her are opened, and the water pours into the lock, gradually filling it up, and raising her with it. At last

it reaches the level of the higher section; the double gates swing open, and she is free to continue her voyage.

As soon as she has crept out of the lock, another barge, which has been waiting, and which is journeying in the opposite direction, moves into the lock, and the gates are closed behind her. The sluices in the gates leading to the lower level are now opened, and the water in the lock sinks with the barge, till it is level with the water in the lower section. The gates are then opened, and the barge passes through.

But, you will say, this must waste a good deal of water. It does so; and, in order to keep the depth of the highest section always the same, a never-failing stream must be led into it. Without this supply the locks could not be worked.

You may perhaps be surprised to hear that, before the introduction of railways, there were three thousand miles of navigable canals in our country alone. And yet Britain was one of the last of the great nations to make use of this means of communication.

In the year 1755, however, the Duke of Bridgewater began the cutting of a canal between Worsley and Manchester, employing as his chief engineer James Brindley, whose name you should try to remember. It was

greatly owing to his wonderful skill in overcoming the difficulties of his task that the people of this country were led to see the advantages to be gained by making canals.

Both the Duke and his engineer were remarkable men. The tremendous expense involved in the making of the canal took almost every penny of the Duke's income for over five years; but, once it was finished, he reaped a rich harvest, as he was able to send into market, at a very cheap rate, the coal obtained from the mines upon his estate.

James Brindley was a millwright; and it was his fame as a clever workman that first drew the attention of the Duke of Bridgewater. After completing the Bridgewater Canal, he was employed in the building of many other water-ways. He was, strangely enough, quite uneducated, and never learned even to read and write; but, in spite of his lack of training, his mind was of no common order.

There are some comical tales told about him. When in a difficulty, he would go to bed and stay there, until he had thought out a way of conquering it, even if it took two or three days to do so. Once, when asked before the House of Commons what would be the use of rivers if all these canals were made, he answered: "To feed navigable canals."

The introduction of railways led to the neglect of British canals; but on the continent waterways have been kept in good repair, and are still greatly used. In old times the barges were towed by men or horses walking along the towpath alongside the canal; but nowadays many of the canal companies have steam-driven barges. In Germany there are over six thousand miles of navigable canals, and in France over seven thousand miles.

As commerce increased, and manufacturing towns sprang up, it became a serious matter to transport from big inland cities to the seashore, or from ports on the coast to large inland cities, the quantities of goods, in the manufacture or distribution of which the inhabitants of the towns were engaged. It was felt that, if ships could bring their cargoes right into the cities, where they were needed, much time and expense would be saved.

In order that this might be done, many ship canals were built, such as the Gloucester, the Berkeley, the Caledonian, and the North Holland. These canals were given depths of from eighteen to twenty feet, with a width at the surface of from ninety to one hundred and twenty feet. Big and spacious as they were then thought, they would be much too shallow for the steamships of the present day.

Mention must be made of two splendid ship canals of more recent date—the Manchester Ship Canal, which has made Manchester a seaport; and the Baltic and North Sea Canal, which enables the German fleet to go from the North Sea to the Baltic, without the loss of time needed to steam round Denmark.

Mention has already been made of a canal joining the Nile to the Red Sea—a canal completed by the early Egyptians some thousands of years ago.

The Egyptians were skilful canal-makers; some portions, indeed, of the canals they made are in use at the present day.

It is said that one hundred and twenty thousand Egyptian labourers died, while making this canal from the Nile to Suez, at the head of the Red Sea, and that even then it was left to be finished by a later monarch. From Zagazig on the Nile, past Bubastis, and through the Bitter Lakes to Suez, its total length was more than ninety-two miles.

The Greek historian, Herodotus, says that when he saw it on his visit to Egypt, it was wide enough to carry two vessels abreast; and another historian, Strabo, who wrote about two thousand years ago, tells us that the traffic of vessels on the canal was enormous. He also tells us that the canal was very deep, and over one hundred feet wide.

After the naval battle of Actium, off the coast of Greece, in which the Roman emperor Augustus defeated the fleet of Antony and Cleopatra, the queen of Egypt tried to escape from the victors by sailing through the canal; but the Nile not being in flood, there was not enough water to float her sixty-two warships.

After the death of Cleopatra the canal fell into decay for many years, but was cleaned out and reopened in the year 600 A.D. by Omar, "The Commander of the Faithful." One hundred and fifty years later it was filled up by one of the Caliphs, so that provisions might not be taken to a vassal, who had rebelled against him.

When Napoleon conquered Egypt in the year 1798, only the embankments were left to tell of this ancient canal; but they aroused in Napoleon's keen mind the brilliant idea of re-opening the canal, and so having a direct route from France to India, by which French troops might be sent to assist the native princes to expel the British.

So much was he taken with the notion that, had he not been recalled to France, he would doubtless have begun the work without delay.

The French engineers employed to survey the possible route of the canal completed their work amidst great dangers—for all the Arab tribes on

the eastern frontier of Egypt were up in arms against the infidels. One curious result of this was that their survey made it appear that the Red Sea was about thirty feet higher than the Mediterranean; and they stated that any attempt to make the canal would result in the flooding of the whole country.

British opinion was strongly against any such canal. Besides the danger to their Indian possessions, it was felt that the opening of a direct route, from the countries of Southern Europe to the Far East, would interfere greatly with our trade.

A good many years later, a committee was formed to go into the question of making a canal from the Mediterranean to Suez; and one of the engineers appointed was the English railway engineer, Robert Stephenson, the son of the builder of the famous *Rocket*.

Stephenson spoke strongly against the scheme, and his opinion was welcomed by the British, who feared that France had some underhand scheme in view by which to ruin our empire in India.

There were people in Britain, however, who saw what an advantage it would be to this country to have a shorter route to India. The only way, during many years, for either goods, letters, or passengers was by the Cape of Good

Hope; and in the days of sailing-ships this voyage took from four to six months.

A lieutenant of the Indian navy, named Waghorn, felt so strongly about shortening the way to India, that he spent seven years of his life, in trying to show that letters might be carried to Bombay or Calcutta by what he called "the overland route" in a very much shorter time than by the Cape.

He at last obtained leave to take at his own cost copies of the letters which had already been sent by the ordinary route. Leaving London, he used to travel with the utmost speed across France or Germany, taking steamer sometimes at Marseilles, and sometimes at Trieste for Alexandria in Egypt. Here he would hire camel or canal-boat to take him on his way to Suez, where he had to wait till a steamer appeared, bringing her cargo up the Red Sea. Upon her he would take passage to Bombay, or any other Indian port. Once, failing to meet the steamer, he sailed six hundred and fifty miles down the Red Sea in an open boat.

After spending all his money and ruining his health, he made it clear that it was possible to deliver letters by this route; and an inquiry was held by the Bombay Government as to whether the Red Sea was navigable. You will be astonished to hear that the sea was decided to

be safely navigable for sailing-ships, but not for steamers. But perhaps this opinion is no more surprising than that of the East India Company —that it was undesirable to convey mails in steamers!

Waghorn, however, was not even yet discouraged. With the help of a few friends at Bombay, he set to work to make the overland route possible for ordinary travellers. In the desert between Cairo and Suez he founded a number of resting-places, erected three hotels for travellers, and built small steamers to take the place of the Nile boats. Then he bought a number of comfortable carriages, and arranged a regular service of caravans.

At length, in 1831, everything was ready; but it was not till 1837 that the British Government took advantage of this much shorter route for the despatch of mails.

For some years before his death, which occurred in the year 1850, his hurried journeys through Egypt, and his attempts to get the overland route into working order, had drawn the attention of a very remarkable man. This was Ferdinand de Lesseps, the French Consul at Alexandria—a man who was then over forty years of age, but whose life-work was not as yet begun.

Many years before this time, he had made

a voyage from Tunis to Egypt in a wretched little sailing-vessel, which took nearly forty days for the voyage. When they arrived at the port of Alexandria, the vessel was put in quarantine—that is to say, compelled to remain outside of the port, because there was a case of infectious disease on board.

During this weary time of waiting, he was visited by a countryman of his own, who brought him to read an account of Napoleon's Egyptian expedition. Included in this work was the engineer's report upon the canal scheme, to join the Mediterranean and the Red Sea.

From that moment the idea of uniting the two seas took hold of the mind of De Lesseps; and for twenty years he thought of it, trying to interest in his scheme powerful persons, both in Egypt and in France.

His plan, however, was different from that of any one who had ever taken the matter up. The idea of the committee upon which Robert Stephenson served was to make a canal, containing many locks, from Suez to Alexandria—a work which would have cost immense sums of money.

If you look at a map of the Old World, you will notice that Africa is joined to Asia only by the narrow neck of land called the Isthmus of Suez. De Lesseps' notion was to cut through

this isthmus, forming, as it were, a narrow strait, and making Africa an island.

This idea had been mentioned many times before, but always as if it could not be done. You will hear further on some of the objections urged against it.

Failing to interest the Viceroy of Egypt, Abbas Pasha, De Lesseps asked one of his friends in Constantinople to try to win over the Sultan of Turkey. The Sultan, however, would not interfere in the matter, not wishing to offend the Viceroy of Egypt.

De Lesseps had retired from public life, when his chance at last came. He was then nearly fifty years of age, but still strong, and as full of courage as ever.

One day, while directing some masons who were working for him, he happened to glance at one of the newspapers just handed to him by the postman. In it he read that Abbas was dead, and that Said Pasha, an old friend of his own, was Viceroy in his place.

De Lesseps lost no time in writing to the new ruler of Egypt, and the reply to his letter contained an invitation from Said Pasha to meet him in Alexandria in November. This was in the year 1854.

When De Lesseps arrived in Alexandria, he was received with the greatest friendship, and

took part in all the brilliant festivities which were going on. But he heard that the Pasha had, some time before, stated that he would never think of making a canal through the isthmus, since he knew it would be displeasing to Britain.

This was not enough to damp the hopes of the Frenchman, though it made him use every possible fair means to win favour with the Viceroy, and so gradually influence him to look with approval upon the scheme. On one occasion, on leaving the Viceroy, he leaped his horse over the parapet of stone surrounding Said's tent — for they were now travelling in state from Alexandria to Cairo.

This incident was made fun of in the English papers; but there is no doubt that it increased the respect of both the Viceroy and his ministers for him, since, like all Easterns, they admired skilful and daring horsemanship.

That very day he mentioned the scheme to Said, and was delighted to find him not only favourable to the plan, but eager to have it carried out.

On their arrival at Cairo, the consuls of the foreign countries were called together, and the scheme was explained to them. All except the British consul approved of it, and a company was proposed for making the canal—a company

which should include people belonging to all the nations interested. Of this company De Lesseps was to be the director.

An important part of the scheme was the making of a fresh-water canal, from the Nile to the canal, and all the land made cultivable by the water of this canal was to become the property of the Canal Company; four-fifths of the workmen were to be supplied by the Viceroy of Egypt; all persons using the water of the sweet-water canal were to pay tolls to the Company, and the Company was also to be allowed to work any mines or quarries in the lands belonging to it.

The canal itself was to be neutral—that is, no nation, not even Egypt, was to have the power to close it in time of war, and the vessels of all nations were to pay exactly the same tolls for its use.

But in spite of this splendid beginning dark clouds soon gathered around. De Lesseps had first of all to obtain the sanction of the Sultan of Turkey, whose vassal the ruler of Egypt was. At this time the Crimean War, in which France and Britain were taking the side of the Turks against the Russians, was going on; and the Sultan was very much under the influence of the British ambassador to Constantinople, Lord Stratford de Redcliffe, one of the ablest

statesmen Britain has ever had in her service—and Britain was against the scheme.

There were many reasons why the British did not wish the canal to be cut. Much British money was being invested in the railway from Alexandria to Cairo and Suez, from which the opening of a canal would take much of its expected income; the scheme was French, and, therefore, in the opinion of many, suspicious; and, finally, one of the most trusted of British engineers, Robert Stephenson, had spoken against it.

Seeing that everything depended upon the Sultan, De Lesseps lost no time in crossing to Constantinople to see the Grand Vizier, the Sultan's chief minister; but as he was entirely under the influence of the British ambassador, no result came from the visit.

Many people honestly thought that the canal could not be cut. The sea at both ends would be too shallow; to dig a ship canal from sea to sea would be far too costly; the canal itself would fill up with sand, and would be very difficult to keep open. The difference in level between the two seas would flood the whole land of Egypt, if the cutting of the canal were begun; and part of the cutting would have to be made through solid rock. These were some of the objections.

After long, weary months, and after visits to Paris and London, De Lesseps at last came before the people of Britain, and in Manchester, Belfast, Dublin, Glasgow, Edinburgh, and, indeed, in nearly every important town in the United Kingdom, held meetings in which he pleaded for help in his work.

To his intense delight he was everywhere well received; but the opposition of Lord Palmerston, the foremost statesman of Britain, could not be overcome.

In the year 1858, De Lesseps yielded to the advice of his supporters, to form the Canal Company, and to sell the shares. Of the eight million pounds needed nearly half was subscribed by the people of France.

It would take too long to tell the whole story of this struggle of one man against such powerful odds; it is enough that at last he won; and no country has benefited more than our own from his success.

The extent of the works was enormous. Two harbours had to be built, with piers, lighthouses, and docks; an army of labourers had to be taken into a dry and sandy wilderness, without a blade of grass, or drop of fresh water, and there housed and kept in comfort; while water to supply their needs had to be brought by a canal, yet to be cut.

Had it not been for the generous help of the Viceroy of Egypt, the task could never have been accomplished. There used to be in Egypt a system of forced labour—at any time the Viceroy could call upon the peasants to do work for him. This power he now used; and eight thousand labourers were set to work clearing out the old canal of which mention has been made.

It was dug to a depth of nine feet, and to a width of forty feet; so that not only did it convey to the workmen on the canal the fresh water they needed, but boats sailed along it selling to them all kinds of goods.

This canal still supplies with fresh water the stations along the canal, including the towns of Port Said and Suez.

De Lesseps' plan was to make a salt-water canal, open at both ends to the sea, and entirely without locks. This was one of the chief reasons advanced by Robert Stephenson against the whole scheme. Such a canal, he said, if there were, as De Lesseps declared, no difference in level between the two seas, would become a mere stagnant ditch, because there would be no current through it.

This was a very real danger; but, owing to the difference in tides and currents between the seas, there is a steady if slow current, from the Red Sea to the Mediterranean.

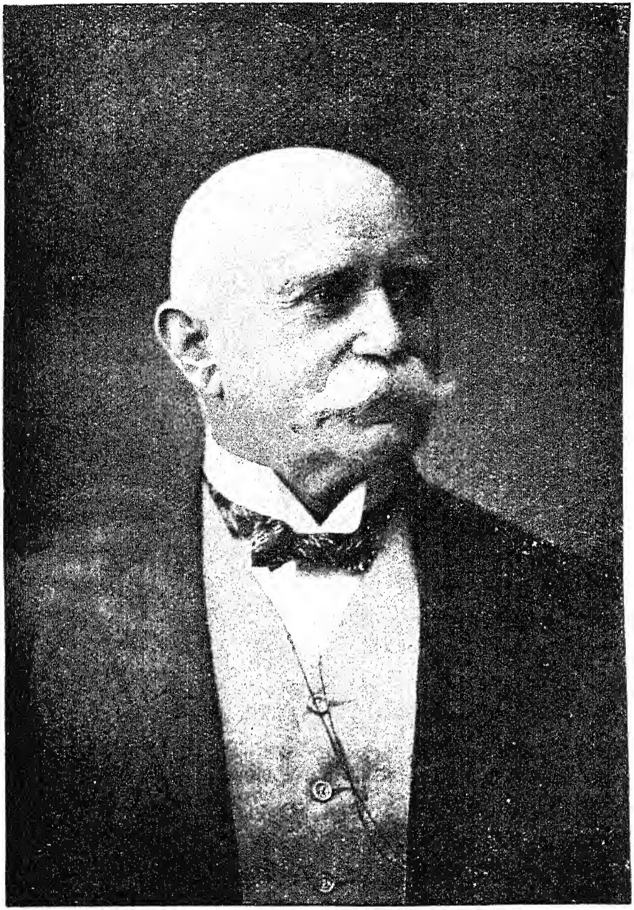

Photo: H. Brandseph, Stuttgart.
M.W.W.

Count Zeppelin.

The cutting of the canal was not begun till 1859; but with such zeal was the work pushed on that it was opened to traffic in 1869.

In those ten years, on the strip of "slob" land dividing Lake Menzaleh from the Mediterranean Sea, Port Said had been built—a town laid out in regular streets and squares, and with a population of ten thousand inhabitants. Two vast breakwaters or moles, each about a mile and a half in length, and of great height and width, had been built to enclose the channel dredged out of the sandy floor of Pelusium Bay, and to keep it entirely free from the silt poured out from the mouths of the Nile.

At the southern end another great seaport, with a population of thirty thousand, had taken the place of the Arab hovels formerly known as Suez; and between these places had been built the little inland port of Ismailia, so named after Said's successor, Ismail; and the canal itself, nearly one hundred miles long and twenty-six feet deep, had been cut, and was ready for use.

So great was the amount of work to be done that, at one time, there were two hundred and eighty-five dredging-machines, scooping out monthly nearly three million cubic yards of mud and sand.

From Port Said to the mainland of Egypt—a distance of about twenty-nine miles—the canal crosses the shallow Lake Menzaleh, its channel being scooped out of the muddy bottom of the lake. A cutting of about two miles through low sand-hills brings us to a second lake, Lake Ballah, which the canal traverses for about eight miles, entering then the deep cutting leading to Lake Timsah, a salt-water lake nine miles in circumference, filled from the canal. Here the fresh-water canal meets the sea canal, and here is Ismailia.

The canal now enters the cutting of Toussoum, and then that of Serapeum, about six miles of most difficult work through a sandy plateau, passing thence to the Great and Little Bitter Lakes, deep hollows in the desert now filled with sea water, and giving over twenty miles of navigable water without needing digging. After traversing the Chalouf cutting, about five miles long, the canal crosses the open country to the head of the Gulf of Suez.

This Chalouf cutting was the worst part of the work, and was left almost to the very last. Here a large mass of rock was reached, which the engineers almost despaired of cutting through. A way was found at last. By banking up the sides and the ends, and turning the water of the sweet-water canal into the enclosed

section, dredgers were got to work, which, with the help of blasting, scooped out a channel of the required depth.

In the work of making this mighty canal, "thousands of men were employed—Dalmatians, Greeks, Croats, negroes from Nubia and Egyptian fellahs, all superintended by French officers. These gangs of men were formed into companies, and paid according to the cubic feet of earth they dug out, some earning five or six, and others only two or three, francs a day. The works were pushed on with great rapidity, asses, men, mules, camels, and steam-traction on railways all contributing towards their completion."

At every five or six miles between Port Said and Ismailia, the canal is widened, so as to form a "siding" where one vessel can pass another safely.

It was at first thought that the cutting of the canal would cost not more than four million pounds. The estimate was afterwards raised to eight millions; but nineteen million pounds were spent upon it before it was finished. If it had not been for Said Pasha, upon whom the heaviest portion of this outlay fell, the work could never have been done.

So heavily, indeed, did the expense press upon Egypt—by no means a wealthy country—that in 1875 Ismail Pasha, Said's successor, found himself compelled to sell the shares he

held—over one hundred and seventy-six thousand. These were bought by the British Government for four million pounds; and a capital investment it has been, not only paying a very large return in interest, but giving Britain control over the canal.

For, though the canal scheme was opposed by the British Government of the time, for what seemed then very good reasons, this waterway has become the high-road to Britain's Eastern Empire, and to her many possessions in the Indian and Pacific Oceans.

The canal was opened in November, 1869; and, in the month of March of the same year, the canal works were visited by the Prince and Princess of Wales—now King and Queen of England.

M. de Lesseps resolved to make the visit an event of some importance. A dinner was arranged at Suez, with band, lines of troops, and illuminations. The next morning, after an inspection of the harbour works, the party was taken on board H.M.S. *Prompt*, a gunboat of one hundred and twenty tons, into the canal itself up to the first barrage.

The next morning the whole party went by train to Chalouf, and crossed the fresh-water canal on a pontoon. At the other side were waiting saddle-horses for the men, and a little basket-carriage for the Princess and her lady-in-

waiting. The deep cutting through the hills was visited, and the work watched for some time with interest.

The wife of an official presented to the Princess a bunch of flowers from the gardens now blooming in the desert; and then by train and steamer they went on to the barrage, or dam, which held back the waters of the Mediterranean from the Bitter Lakes. Upon their arrival the first sluices were opened, and the salt water gushed through. It was five months, by the way, before the whole of this hollow was filled.

After passing the night in the Viceroy's kiosk near Ismailia, the Prince and Princess completed their survey, embarking at Port Said upon the Viceroy's yacht.

In spite of this visit of their future king and queen, the British Government did not send any one to the opening ceremony, to which several sovereigns went, and to which all the civilised nations of the world had been invited to send warships.

Even now there were difficulties to be overcome before the opening. First of all the fireworks, which had been stored in the timber-yard in the middle of the town, caught fire, and in exploding nearly burnt down the place. It was all that two thousand soldiers could do to quell the fire and prevent disaster.

Fifteen days before that fixed for the opening, the engineers informed De Lesseps that they had come upon a rock in the Chalouf cutting, rising fifteen feet above the bottom of the canal, and so extremely hard as to break the buckets of the dredgers.

"Go and get powder at Cairo," cried De Lesseps. "If we cannot blow up the rock, we will blow ourselves up."

On the very evening before the opening, news came that an Egyptian frigate had run aground in the canal, and could not be removed. Everything possible was tried in vain; and at last, by the orders of the Khedive, she was blown up!

The opening ceremony was a magnificent spectacle. First came the blessing of the enterprise by the Ulema, the chief priest of the Mohammedans, the Archbishop of Jerusalem, and the confessor of the Empress of France. This ceremony took place in the presence of the Emperor of Austria, the Empress of the French, the Viceroy of Egypt, the Princess of Holland, the Crown Prince of Prussia, the Grand Duke Michael of Russia, with a crowd of ladies and gentlemen of nearly all the nations, in handsome dresses and grand uniforms. Bands and troops and flags were everywhere, and crowds of cheering people.

On the next day a procession of nearly forty

vessels, the French Imperial yacht leading, and ships of all the European powers following, passed through the canal to Ismailia. Here they stayed for the night, passing during the next day to the Bitter Lakes, and thence on the day following to Suez.

At Ismailia a grand ball was given by the Khedive to all his guests, and was opened by Count de Lesseps, with the Empress of France as his partner.

About ten years after this success De Lesseps began a still greater feat—the joining of the Atlantic and Pacific Oceans, by means of a canal through the Isthmus of Panama. Sixty million pounds were sunk in this work, which, however, failed.

For this failure De Lesseps was blamed; and, since he was responsible for the loss of the money, he was sentenced to five years' imprisonment at the age of eighty-eight. He was, however, too ill to undergo this sentence.

There is little doubt that things had been mismanaged by those whom he trusted; but the whole of his former career is proof that he himself was innocent of any intention to misuse the money given into his care.

In the following year the life of this great man, whose work has benefited all mankind, ended in the gloom and ruin of a disastrous enterprise.

III.—Count Zeppelin.

THERE are, roughly speaking, three great classes of living creatures—those which live and move on the land, those which swim in the water, and those which fly through the air. We ourselves belong to the first of these classes—the solid earth is our dwelling-place, and upon it we are fitted to move.

From the earliest times, however, man has been more or less at home in the rivers, lakes, and seas, where dwell the finny and scaly creatures to which we give the general name of fish; by movements of his arms and legs he has been able to propel himself through an element not properly his own, supported partly by his air-filled lungs.

But he has never, until quite lately, been able to fly as a bird does through the air, above both earth and sea, though he has often pictured human beings sweeping with great wings through both air and space. He has been prevented from flying chiefly by one thing, the heaviness of his body. In the water, this does not matter very much, as he is provided

by nature with a compartment containing air —his lungs—making him bulk for bulk lighter than the water which he displaces.

But, in order to float in air, he would need to have within himself, or to be attached to a compartment or bag containing some gas so much lighter than air that, bulk for bulk, he and the bag would be lighter than the air they displaced; or he must find a way of lifting his body as birds and insects raise theirs.

In the case both of birds and of insects, the body raised is heavier than air, as is seen when a bird is shot, or the wings of an insect injured, the flyer falling at once to the earth.

Only lately have men been able to invade the realm of the winged creatures; but it is many, many years since men sent up into the air, and made to float securely at great heights above the ground, various objects heavier than air itself.

Ages and ages ago, long before men had discovered how to write down their doings, so that people coming after them should read their life-story, the two nations of the East, the Chinese and the Japanese, sent up into the air wonderful constructions of paper and other light fabrics, stiffened with stout ribs of cane and bamboo.

Even to-day kite-flying and kite-fighting are favourite sports among young and old in China

and Japan. Kites in the form of dragons, and fishes, and birds, soar into the air, and are guided by their owners till their string crosses that of a rival, sawing away till one or the other is cut through, and the kite, no longer supported, falls to the earth.

If you had not known a good deal about kites since you were little children, you might have been inclined to say, "Why should a kite fall when the string is cut?"—and at first sight the question is rather puzzling.

A moment before, the kite was pulling hard against the string, trying to soar higher still, and the man or boy was putting out a considerable amount of strength, to hold it down; and yet, now that the string is broken, and it is at liberty to soar as high as it pleases, down it comes tumbling like a bird with a broken wing. Why should it do so?

Without the string, the kite cannot maintain itself in such a position that the wind, acting against it, forces it to rise. If the kite could place itself at the proper angle to the wind's direction, it could stay above the earth as long as the wind lasted; and, if it could drive itself at such a pace in a calm, that the pressure of the air, against its surface, was equal to that of a strong breeze, it could stay up as long as it chose to use that force.

Now, a bird is able to do just what a kite would have to do in order to keep flying above the earth. It is very light compared with its size—even its bones are hollow and contain air—and it has a wide spread of wing and tail, which it can place and maintain in a position that enables it to soar against the wind, or with which it can force itself through the air, at a pace causing pressure enough to raise it.

If, then, a man could make himself part of a huge kite, which he could control as a bird controls its wings and tail, and drive through the air at a fair speed, there is no reason why he should not fly.

But it will occur to you, after a little thought, that anything lighter than the air will rise above the earth, without needing any push from the wind. The difficulty is to find anything lighter than air. Feathers and straws and bits of paper are, of course, heavier than the air, and float upwards only when pressed by a strong breeze, or by the upward rush of warm air.

You have all seen a piece of paper fly wildly up the chimney, driven up amongst the smoke and hot air rising from the fire. There, at any rate, we have one useful fact—hot air rises through cold air. You probably know

the reason: air when heated expands, or takes up more space, and therefore becomes, bulk for bulk, lighter than the cool air.

The air breathed from your lungs is very warm; it is, moreover, loaded with vapour, and is therefore much lighter than the air outside. No doubt you have often amused yourself by blowing soap bubbles, and watching them float away, glowing with rainbow hues in the sunshine.

These bubbles are really little hollow globes or balls of tough soap lather, filled with the hot air from your lungs; and, until the air within them is as cool as the air outside, or until they strike against something which shatters their frail sides, they will float bravely.

In the year 1783, two brothers, named Joseph and Stephen Montgolfier, found that air, heated to almost twice the heat of the human body, expanded to twice its ordinary volume—that is, it would fill double the space it did when cool; so that a ball, filled with this heated air, contained only half the weight of air contained by a ball of equal size filled with cool air.

It struck them that if the ball were made of any very thin, light substance, the difference in weight between it when filled with hot air,

and the equal bulk of cool air it displaced, ought to be enough to cause it to rise above the earth. Acting upon this idea, they got some very light, but air-tight material, and made a small balloon—"balloon" comes from a French word which means a football, and has been so twisted in its meaning that it is now used for any round hollow body. This little balloon they filled with hot air, and were delighted to see it rise to the ceiling of their room.

After a few more trials they made a globe of linen, one hundred and five feet round, and told their neighbours to come to see it go up. The balloon was carefully held, so that its mouth was over a fire fed with bundles of chopped straw; and when fully distended by the hot air it was released. To the wonder of those looking on, it rose at once fully a mile into the air, and then, the air within it becoming cooled, it dropped to earth again at a distance of more than a mile.

This experiment made quite a sensation; and people gave money to pay for the making of a balloon of silk to be sent up from Paris.

But Professor Charles, to whom had been given the task of sending up the balloon, knew of a gas, so much lighter than air that a balloon filled with it would be only one seventeenth the weight of a balloon filled with air.

This was hydrogen gas, the lightest of all known substances.

Coal-gas contains a large proportion of hydrogen and is now almost always used for inflating balloons, but the only way of making hydrogen then known, was by pouring sulphuric acid and water upon iron filings.

This was a very slow way, especially with the poor apparatus which the Professor had; so that days passed before the booming of a gun told the balloon was about to ascend. To obtain the amount of gas needed, nearly one thousand pounds of iron filings had been used, and half that quantity of acid.

The balloon had a sad fate. It rose to the height of over half a mile, in the presence of a vast crowd of people, and then sailed gaily away. But so poor was its construction that in less than an hour it came to earth. It descended in a country district, where nothing of the kind had ever been seen before; and the peasants were filled with terror as it settled on their fields. They were certain it was some strange and terrible monster; so, seizing any weapon that came handiest, they fell upon it savagely and cut it to ribbons.

People soon saw that if a balloon large enough were made, it was possible for a man to be carried up into the air by its means. You

can work out the problem for yourselves, if you like. Suppose the difference in weight between a balloon filled with ordinary air, and a balloon filled with hydrogen gas, to be two hundred pounds, and that the weight of the car, ropes, netting, and everything else is one hundred pounds, it would take another hundred pounds to keep the balloon from rising.

If, then, you were to put a small boy weighing only sixty or seventy pounds into the car, and unfasten all the mooring-ropes, the balloon would rise at once, and the small boy would have the pleasure of looking down upon you all, from a height of some thousands of feet.

Thus there are three ways in which a man can ascend into the air. He can build a kite, so large that he can be taken up with it in a basket hanging from it like a kite-tail; or he can make a machine as nearly like a bird as possible, with wide-spread wings and a small light engine working a propeller to drive it against the air, and so make it rise; or he can construct a big balloon, fill it with hydrogen gas, and be taken up in its car.

Lately much attention has been paid to all three of these methods, and most wonderful progress has been made. It is now possible for a man to take a trip through the air, either by kite, or flying-machine, or in a balloon.

One of the first to study the making and flying of giant kites was Mr. W. A. Eddy, who, towards the end of the year 1893, sent a big kite more than a mile into the air. This was something like kite-flying; but, three years later, he was the proud possessor of a kite, which had looked down on the earth from a height of nearly two miles.

The success of Mr. Eddy's kites set other people trying: a d in the beginning of 1899, a kite was sent up from the Boston Observatory to a height of nearly two and a half miles. Boston, as you know, is in North America—Mr. Eddy himself is an American.

Near Boston is Bunker's Hill, where a battle was fought between the British and the New England colonists, in the war which ended in the independence of the States; and it was in Boston Harbour that the famous fight took place between the *Chesapeake* and the *Shannon* in the war of 1812, when the *Shannon*, the British ship, beat the *Chesapeake*, the American ship, in exactly fifteen minutes.

Mr. Eddy's kites are rather like a big home-made kite, such as our country lads make out of brown paper and cane, except that the material used is much stronger, and the kites are wider and have no tail. In the middle is a large hole to allow some of the air to

M.W.W

A British Airship.

Page 95.

pass through, to lessen the pull on the string.

He has made kites big enough to take up a camera; and he has a clever arrangement of strings, so that he can take a snapshot whenever he likes. In this way, he has taken some wonderful photographs of places over which his kites have been flying.

You can easily see what important work such kites might do in war-time. Whenever the wind was blowing favourably, a kite could be sent up carrying a camera, and pictures might be taken of the very things the enemy most wished to hide, such as masked batteries, bodies of reserve troops, or the weak spots in their defences.

Another awful use to which these kites might be put, would be the dropping of explosives upon an enemy's camp or warships; but it is to be hoped the nations will agree that such a thing shall not be allowed.

Another form of kite was invented by an Australian named Lawrence Hargrave, a queer-looking thing like a big shallow box with the bottom knocked out. The frame of the box is very light, and the covering is of light, but strong cloth. Several of these boxes are used, fastened together to form one kite of many compartments. Their lifting-power is so great

that it has been possible to send a man up into the air by their means.

Major Baden-Powell has carried out many experiments with these giant kites. He believes they will be of far more use in war than any form of balloon. They are not nearly so dear; they are much more easily carried from place to place; if bullets pierce them no great damage is done, whereas in the case of a balloon the gas would escape, and the whole fabric come to the ground. Both he and Lieutenant Wise of America have ascended into the air by means of these giant kites, using strong bamboo for the frame, and very thin piano-wire instead of string.

But, interesting and useful as kites are, the problem of transit through the air can never be solved by them; for, even when three or four miles of wire have been let out, and the kite soars two miles or more above the surface of the earth, it can only safely come down again at the spot from which it started. For sailing through the air, we must still depend upon either flying-machines or balloons, or upon both together.

You have doubtless all, at one time or other, amused yourselves by sending flat stones skimming over the surface of smooth water; and you know that, as long as the stone is

going at a good rate, it may strike the water many times without sinking into it. That is to say, a stone, which is much heavier than water, is supported by water and prevented from sinking, as long as it passes quickly from one point of support to another. As soon as it rests for more than a fraction of a second, down it goes.

Almost exactly the same thing takes place when you send a sheet of cardboard skimming through the air. As long as the sheet is in motion and passing rapidly, as it were, from one point of support to another, the air will hold it up; but, as soon as the force which sent it skimming is spent, and it tries to rest upon one small portion of the air, it sinks to the ground.

Professor Langley of America tested the truth of this when applied to large, heavy sheets of metal; and found that, once he had these sheets in motion, it needed very little power to keep them floating on the air at a good speed.

He now set to work with a flying-machine, which should be so light, and able to fly at so great a pace, that it would be supported upon the air. Year after year he worked on, finding out the best materials of which to make his machine, the strongest and lightest possible

engine with which to drive it, and the shape best suited for flight.

He made at last his "Aerodrome" with flat wings or "aeroplanes" as they were called, and with a light little steam-engine, weighing only seven pounds, and yet having a force equal to one horse-power. The whole machine weighed only thirty pounds, and, after many trials, Professor Langley had the joy of seeing his "Aerodrome" fly through the air for over half a mile.

Another flying-machine has been invented in England by Sir Hiram Maxim—a big machine, with many aeroplanes, showing a surface to the air of four thousand square feet, and with a steam-engine having a force of three hundred and sixty-three horses. This huge machine was made to carry three men; and, on the rails laid down for its first trip, it went at the rate of thirty-six miles an hour, though it has never yet been launched into the air.

In both these machines the steam-engines were made to work screw-propellers, which, by turning in the air as a ship's propeller turns in the water, forced the machine forward.

Many other forms of flying-machine have been invented; but all, or nearly all, depend upon the two principles of the aeroplane and the propeller.

A German named Lilienthal was the first to invent the gliding-machine, in which large wings, usually with curved surfaces, are made to support a man's weight, and so enable him to glide gently, and in a sloping direction, to the ground from the crest of a high hill or the top of a wall.

These machines, however, are very dangerous, Lilienthal himself falling and being killed while performing one of his flights. An Englishman named Pilcher also lost his life by falling from one of these gliding-machines.

It was in 1896 that Lilienthal was killed; and an account of his death was read in an American paper by two brothers, who for some years had been much interested in the problem of human flight. Their names were Wilbur and Orville Wright, the sons of a clergyman living in the State of Ohio.

The two brothers were so deeply interested in the story of Lilienthal's attempts to fly that they sent to Germany for a copy of his book upon flying, and flying-machines, and studied it carefully, afterwards amusing themselves by making gliding-machines, and spending their holidays in trying to fly.

In 1903, they made a machine which, though very like their former gliding-machines, had a powerful little engine of twelve horse-power;

and, supported by this machine, one of the brothers actually flew for almost a minute against the wind.

Since then they have made some hundreds of flights, bit by bit improving their machine, and their method of propelling it, until now they assert that they have a machine which will safely and easily carry a man for hundreds of miles. Quite recently they have sold their idea to the War Department of the United States.

These machines, which depend chiefly upon their speed through the air to keep them from tumbling to the ground, are very dangerous. Any sudden stoppage of the motive power, or breakage of one of the aeroplanes, would bring man and machine to the ground.

In order to guard against such an accident, many inventors have tried to make a vessel composed of balloon and flying-machine. Some have fitted engines, propellers, and rudders to the cars of balloons, so that, while the gas-bag supported all the required weight, the people in the car might drive it in any direction they pleased, thus making it a dirigible balloon, that is, one which it is possible to direct.

Others have employed a gas-bag big enough only to keep the machine from falling to the ground, and have fitted aeroplanes and powerful engines to the car. In this case the gas-bag acts

in the same way as the life-belt fastened round a swimmer's chest. If he should stop swimming, through faintness or cramp, the belt would hold his head above water.

To this kind of vessel the name "air-ship" has been given; and many people are strongly of the opinion that, in the not very distant future, fleets of airships will be sailing from country to country just as the great liners do now across the ocean.

But the form given to dirigible balloons is altogether different from that of the old-fashioned floating balloon. It was early found that to attempt to push through the air a pear-shaped gas-bag, by means of a propeller attached to its car, was hopeless: the balloon drags behind the car, threatening to overturn the whole machine.

The first dirigible balloon of any account was that of M. Giffard. This balloon, in which the inventor ascended from Paris in 1852, was about forty-eight yards long by thirteen in diameter. In the car he had a three horse-power steam-engine, by means of which he worked a two-bladed screw, about twelve feet in diameter. Conditions must have been very favourable, as he drove the machine along at the speed of nearly seven miles an hour.

During the siege of Paris by the Germans in

the years 1870 and 1871, sixty-four balloons, each conveying on the average two passengers and five or six hundredweight of letters, were sent out from the city. Homing pigeons were also carried, and by their means news from the outside world reached the citizens.

It became clear to the Parisians that much help might have been given them, if steerable balloons could have been used; and during the siege M. Dupuy de Lôme was entrusted with the task of making one, which, however, was not completed until the city had opened its gates to the enemy. In the following year a trial trip was made, in which eight men were employed to turn the propeller, an engine being thought too dangerous; but, though the results were encouraging, the French Government did not think it right to spend any more money over the experiment.

Serving as a general in the German army during the siege, was a man to whom balloons were of the utmost interest; and we may be sure that few of the daring voyages from Paris escaped his notice. The name of this man was Count Von Zeppelin, and, for nearly thirty years after the conclusion of peace, he devoted all his time, and large sums of money, to the task of making a useful machine.

During those thirty years many others were

at work in France, America, and England, some trying to improve the flying-machine, some trying to fit motive power to the aeroplane or gliding-machine, and others pinning their faith to the old-fashioned balloon, drifting at the mercy of the winds.

From all their attempts Count Zeppelin learnt valuable lessons.

In 1893, Gaston Tissandier ascended from Paris in the first airship, in the driving of which electric power was used. His balloon was ninety-one feet in length, with a diameter of twenty-nine feet, the ends being pointed. Under the balloon was swung the car, depending from twenty ropes tied to a netting enclosing the envelope. The car weighed twelve hundred pounds, and carried eight hundred and fifty pounds of ballast, while the balloon was six hundred pounds in weight. The two-bladed screw was rather over nine feet in diameter.

But, though this was an advance on former designs, the old faults still remained.

Other notable airships were those of Lebaudy, of Santos Dumont, and of Andersen.

That of Lebaudy was such a success that it was bought by the French Government, and two others were made on the same plan.

Santos Dumont, a South American, who raised high hopes in the hearts of the Parisians,

made an airship, which carried a small gasolene engine. Under the machine was fixed a light spar on which he rode bicycle-fashion. Later on mention will be made of other airships of his invention.

All these failures, or partial successes, were carefully noted by Count Zeppelin; and he came to the conclusion that failure was caused by defects which it was possible to overcome.

One of the most serious was the ease with which the envelope could be broken. It was made of varnished silk, or of some fabric treated so that gas could not leak through; but, at the same time, it was easily rent or pierced, and was more or less damaged by heavy rain.

To get over this, Count Zeppelin planned an airship, which should contain seventeen gas envelopes, so that a rent in one or even in two or three would not upset the machine; and he covered each of these compartments with a tough, parchment-like outer skin, very strong and quite waterproof.

The second defect was attaching both rudder and propeller to the car, which was thus made to drag the balloon after it, with straining cordage, and risk of accident.

The remedy for this was to attach motor and rudder to the balloon itself; and, since this could be done only by making the envelope

strong and rigid, Count Zeppelin built up a framework of that wonderfully light metal, aluminium, having seventeen compartments for his seventeen balloons, covering the whole with the strong, parchment-like material which has been mentioned before.

Under this stretched a narrow gangway, three hundred and forty-six feet in length, carrying the two boat-like cars of aluminium, which contained the machinery.

This airship, the largest ever built, measured, when finished, four hundred and twenty feet from end to end, and weighed eleven tons. The engines used for driving the ship were two Daimler benzine engines, each of sixteen horse-power.

The monster airship was built at Friedrichshaven on the shore of Lake Constance; and it was over the waters of that inland sea that she made her first trip. She had cost over ten thousand pounds to build, and every portion of her was the result of the most intense thought and tireless experiment; so you will understand what an anxious undertaking was this trial trip, to the man who had built her.

Every one of the balloons had a safety-valve, so that there should be no bursting from the expansion of gas in the hot sunshine; and the filling and placing of these gas-cells was

carefully carried out by officers of the German army, specially trained to the work.

During the evening before her trial trip, she was taken out of the shed and examined; her engines were started, and her propellers set revolving; and the men, whose work it was to cast off and hold the mooring-ropes, were exercised in their duty.

The next day was so hot that the trip was put off until the evening, when, with a crew of five, the airship rose smoothly and steadily to a height of thirteen hundred feet above the lake. Here she was made to describe a circle, in order to test all the parts of her machinery.

When she had covered a distance of nearly four miles, in little over a quarter of an hour, one of the aluminium portions of her steering-gear broke, and it was thought best to bring her down to the lake.

So cleverly was the hydrogen allowed to escape that she settled upon the surface of the water like a wild duck, her boat-like cars floating, and her body remaining a few feet above the water. A pole sticking up out of the lake caught in the outer cover of the airship, and had to be sawn off, but at last she was safely housed again, and the trial trip brought to a close.

The accident of the steering-gear showed that aluminium would not do for parts which might

get sudden jerks and strains, and that it would be better, in spite of the greater weight, to use tough bronze instead.

The rudders were four in number, two at the front and two behind. As in the case of the gliding-machine of the brothers Wright, it was found that the rudders in front were the more important, doing nearly all the work. As a clever American once put it—in the bird the tail is carried behind, but in a flying-machine or airship the tail must be in front.

The ballast used was chiefly water, and was stored between the upper and lower floors of the cars. The advantage of using water-ballast is that it can be released at once, and yet without any dangerous jerk, by simply pulling out a plug; and, since the lives of all on board may depend upon a speedy lightening of the ship, this is a most important point.

The speed expected from his airship by the Count was about seventeen miles an hour, enough to enable her to face and make way against any ordinary breeze; that is to say, on seventy out of every hundred days, she could be driven in any direction her captain pleased.

The next year Von Zeppelin was given the Order of the Red Eagle by the German Emperor, for his ability, courage, and untiring perseverance.

In this same year, 1901, M. Santos Dumont

steered his balloon round the Eiffel Tower in Paris, against a wind blowing at the rate of about ten miles an hour, thus winning a prize of four thousand pounds.

In four years this inventor built no less than six airships, each different from the others. Most of his balloons have been long in shape, with an inner balloon filled with air, in order to give steadiness to the gas-filled outer balloon. His engines have usually been like those used in motor-cars, getting their power from petroleum spirit.

A very successful airship was that made by the brothers Lebaudy. This machine went well from the very first, making several trips of twenty or thirty miles. The French thought so much of it that they bought it for use in their own Balloon Corps, and put it through a number of severe tests. So well did the airship stand these tests that the French Government built two others on the same lines, one of which, the "Patrie," with a motor of seventy horse-power, has a speed of thirty miles an hour.

In 1903, Mr. Spencer crossed London in his airship, Mellin; and during that and the following year Dr. Barton made an airship at Alexandra Park, which was propelled through the air by thirty aeroplanes, driven by a motor of forty-seven horse-power.

An airship, the "Nulli Secundus"—"Second to None"—has been built for the British army, and a successful trip was made from Farnham to London. A heavy storm of wind and rain, however, proved too much for her covering of goldbeaters' skin, and experts are now deciding how her defects may be made good.

In the meantime, Count Von Zeppelin had fitted to his airship motors of eighty horse-power, each driving twin-propellers carried at the sides of the machine.

This increase of power has resulted in an increase in speed; and the airship has travelled through the air for two hundred and twenty miles at a rate of thirty miles an hour. It has also held its position against a wind blowing at the rate of thirty-three miles an hour.

All things considered, it seems likely that the "Zeppelin," as this machine is called, has pointed the way for future airship builders, and that, in buying her for military purposes, the German Government has secured a terrible engine of war. An airship, able to carry three tons of explosives, and to travel at the rate of thirty miles an hour, high above the range of the guns at present in use, must play a most important part in the next war undertaken by the German Empire.

M. Santos Dumont has said, "Aerial cruisers

will change warfare altogether, and the nation that first possesses one will be master of the world."

If this be so, Count Zeppelin has added enormously to the military strength of his country.

Some time ago, Messieurs Deutsch and Archdeacon offered a prize of fifty thousand francs—about two thousand pounds—to any one who would cover, in an aeroplane heavier than air, a circular course of one kilometre—about eleven hundred yards—and the honour of winning it has fallen to a young Englishman, Mr. Henry Farman, the son of the Paris correspondent of a British newspaper.

Mr. Farman's aeroplane consists of a central box-kite formed of two planes, behind which stretches a light iron framework, carrying another box-kite with wings. This second box-kite acts as the tail, and keeps the machine steady, its wings preventing any violent rocking. It also carries the vertical rudder, by which the aeroplane can be turned to right or to left.

Between the two planes of the front box-kite are placed the motor, and the seat of the aeronaut. Right in front is the horizontal rudder, by means of which the machine is directed upward or downward.

The trial was carried out on the military

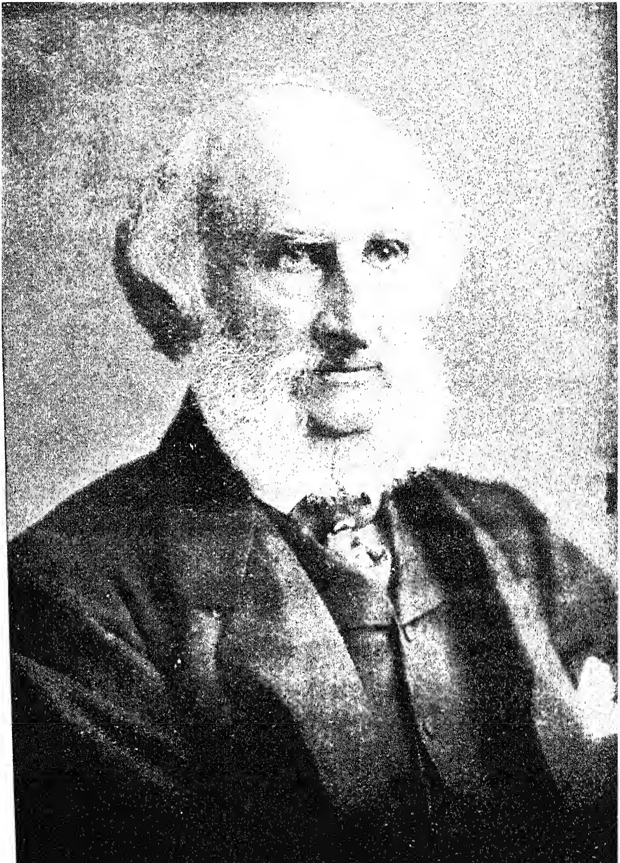

Photo: Elliott & Fry, London.
M.W.W.

Sir Donald Currie.

parade-ground at Issy-les-Moulineaux, and was under the direction of the Aero Club of France.

After running along the ground for about twenty yards, on the wheels fixed beneath its framework, the aeroplane rose easily into the air, and flew at the rate of about twenty-five miles an hour towards the two posts, about fifty yards apart, and about five hundred and fifty yards from the starting-post, which formed the turning-point.

If the machine was to fail at all, it was expected to fail here; but, rising to a height of rather more than twenty feet, the aeroplane sailed gracefully round, keeping perfectly level, and returned to the starting-point at a speed of over thirty miles an hour.

Now came the second serious test. Could it land safely? Stopping his motor, Mr. Farman dropped gently to the ground a few yards beyond the post, thus proving that his machine was completely under control.

Notable, however, as is this success, there are not wanting those who point out that the aeroplane is like a ship, which requires a speed of between twenty and thirty miles an hour to keep it from sinking, that it can only safely be used in a calm atmosphere, and that its motor must be able to develop at least one hundred horse-power for every ton of its weight.

IV.—Sir Donald Currie.

THE record-breaking runs of the two turbine steamers, the *Lusitania* and the *Mauretania*, bringing back to Great Britain the blue ribbon of the Atlantic, have drawn much attention to the company to which they both belong, and to its splendid service during, more than half a century, in the carrying of passengers and mails across the western ocean.

When in 1815 Samuel Cunard made an agreement to carry the mails from Falmouth to the Bermudas, Boston, and Newfoundland, in the old-fashioned sailing packet-boats, he little thought that nearly one hundred years later a fleet of steamers, larger and swifter than any the world has ever before seen, would be running under his name between England and America, with thousands of passengers and millions of letters.

Closely connected with the history of the firm founded by Cunard is the name of Sir Donald Currie, who, from 1843 to 1862, took a leading part in its development. When he joined the Cunard Company's service, no other steamers

but the three Cunarders, the *Britannia*, the *Caledonia*, and the *Arcadia*, had any regular trade across the Atlantic; so that he was put in charge of all the mail and passenger traffic between the United Kingdom and America.

Before speaking, however, of Sir Donald Currie's life-work, it will be interesting to trace the history of navigation, and to examine into the causes which brought about the trans-Atlantic trade of the present day.

In nearly all school histories, special mention is made of the coracles of the early Britons—those hide-covered wicker-work boats upon which the early inhabitants of our country crossed rivers and perhaps lakes; so that one might be excused for thinking that only in Britain were these frail barks to be found.

But the history of nearly every nation contains accounts of such rude craft; while, even nowadays, the natives of many savage lands use boats or canoes little if any more skilfully made.

The skin kayak of the Greenlander and the birch-bark canoe of the Red Indian are made on much the same plan—a framework covered with a tough and supple skin.

The dug-out canoes of the South Sea islanders, and of many savage or half-savage tribes in Asia and Africa are, however, something very different. They are possible only in countries

where trees grow to a very large size. In the Pacific Ocean they have been brought to a high pitch of excellence, being made of great length and fitted with an out-rigger to enable them to float, even upon a stormy sea, without fear of overturning.

It is more than likely that some of the earliest attempts at navigation, either of rivers or of arms of the sea, were made upon rafts composed of logs, laid side by side and roughly bound together. Upon such craft oars would first be used, as there was not only the steadiness needed for rowing, but also the width. All canoes are driven through the water by means of paddles; and, since boats are propelled by oars, there is some reason for deciding that boats—and therefore ships—have sprung rather from rafts than from canoes.

But, while it is true that the early Britons used coracles of wicker-work and hide upon the inland waters, it is known that, even at the time of the first Roman invasion, they had war-vessels built of oak, with timbers nearly a foot thick, which they moved through the water by oars and by sails of leather. Whether these war-vessels were of their own invention, or whether they were copied from those of the pirates or sea-robbers who had already visited the shores of Britain in their long-ships,

we cannot now find out. The only certain thing is that, in these ships, the Britons had crossed to the aid of their neighbours the Gauls, in their fierce struggle against the Roman invaders.

Long before this time, however, the nations round the eastern end of the Mediterranean Sea had built ships; and there is some likelihood that people living on the southern and south-eastern coasts of Asia had vessels, in which they ventured out of sight of land.

The earliest ship of which we have any account is, of course, the Ark; and, from the careful account of it given by Moses, we may gather that, to the Egyptians of his time, the art of ship-building was well known.

During the reign of Solomon ships sailed from ports, both upon the Mediterranean Sea and upon the Red Sea, to far-off lands; yet, in the time of the Romans, the art of navigation was advanced little beyond the coasting voyages described in the Acts of the Apostles.

Those bold and hardy seamen, the Phœnicians, had, for many years before this time, carried on a vast trade along both shores of the Mediterranean, planting colonies for trading purposes on the coasts both of Europe and of Africa, and even venturing into the Atlantic Ocean, and round to the shores of Britain.

At this time, and for many hundreds of years afterwards, the whole known world consisted of the northern portion of Africa, the southern and western portions of Europe, and the western portion of Asia; so that the trade of the world passed chiefly through Mediterranean ports, in one or other of the three continents surrounding that inland sea.

For warlike purposes the slowly-moving sailing-ships were quite unsuited; and nearly every nation had its fleet of swift, strong galleys, or long-ships, moved through the water by gangs of slaves toiling at the oars or sweeps. Of these galleys the Roman triremes were perhaps the most powerful. In these vessels there were three banks of oars and rowers, and, along a gangway, running the whole length of the ship, slave-masters stood with terrible whips, with which they cruelly lashed the weary or lazy oarsmen.

The aim of the commander of one of these war-galleys was to drive the sharp prow of his vessel with such force into the side of the enemy's ship, as to sink her at once, or, if that could not be done, to crash through her banks of oars and so disable her.

Galleys much like these were used for centuries by nations living round the Mediterranean, especially by the pirates of Algeria, and by

the French and Spaniards; and, in some of our wars during the eighteenth century, our frigates were often attacked by a crowd of these dangerous craft.

No history of navigation, however brief, would be complete without speaking of that wonderful city, Venice, the one-time mistress of the Mediterranean. Under the shelter of the Roman power, the Veneti, a tribe living at the head of the Adriatic Sea, partly on the mainland and partly on the islands which cluster together near it, made great progress in art and commerce; but, when the empire began to fall to pieces, the savage Huns and Goths from the north not only destroyed the state, but forced the few persons left to seek refuge on the islands.

Here at first the people led a wretched life, living chiefly on fish, and trading only in the salt obtained from the water of the lagoon in which their islands were situated.

Gradually, however, they became known as skilful boatmen and sailors, navigating the canals and water-ways of northern Italy, and little by little building up an island city, of which the streets were water-ways and the carriages gondolas.

Taking advantage of their splendid position at the head of an arm of the Mediterranean,

pushing right into the heart of Europe, they slowly built up a trade with the East.

For many years they carried on war with the Lombards, a Gothic people who had overrun the north of Italy; and their victories brought them fame and increased power.

In the year 809 they made a treaty with the Emperor of the Eastern Roman Empire, whose capital was Byzantium, now Constantinople. King Pepin of the Franks, against whom the treaty was aimed, invaded the Venetian lagoons, got himself and his force into confusion amid all the narrow winding channels and marshes, and was defeated.

The bringing from Alexandria to Venice of the body of St. Mark, in the year 829, benefited the city, thousands of rich pilgrims visiting the shrine every year.

The city now prospered so wonderfully that, in 1099, she was able to fit out a fleet of over two hundred and seven ships, to rescue the survivors of the first Crusade.

The Venetians did not, however, content themselves with carrying goods prepared by other peoples. They began to manufacture for themselves, and gained fame for their glass and silk. Their buildings are still the wonder and delight of all who visit the city.

Venice was ruled by a Doge, as he was called,

chosen by the people. The wealth and power of the Republic continued to increase until the thirteenth century, when she began her long war against the Genoese. If you look at a map of Italy, you will see that, while Venice is at the head of the Adriatic on the eastern side, Genoa is at the head of the Gulf of Genoa on the western side.

A struggle for the mastery of the sea took place between the two cities; and, at one time, between 1350 and 1380, Venice appeared humbled to the dust—her fleet was destroyed, and the Genoese sailed up the Adriatic, meaning to destroy the city itself. Owing, however, to the courage of the Venetians, the Genoese fleet was at last surrounded amongst the islands, and forced to surrender.

The next century saw the decline of Genoa, and the entry of the Republic of Venice upon a long series of wars, which drained her of both men and money, and turned the thoughts of her people to warfare, rather than to the trade and commerce which had been the source of her prosperity.

To complete her downfall, there occurred, towards the end of the fifteenth century, two events which almost at once turned trade from its old routes, and gave to the western nations of Europe the position so long held by "The Bride of the Adriatic."

The discovery of the New World by Columbus in 1492, and of the ocean route to the Indies by Vasco da Gama in 1497, shifted the centre of trade to the Atlantic sea-board; and for more than three-quarters of a century Spain was mistress of the world.

The conquest of Mexico by Cortes, and of Peru by Pizarro, laid both North and South America at her feet; gold and silver in vast quantities flowed from the conquered countries into the coffers of the King of Spain, enabling him to build a fleet, and to raise an army, vastly more powerful than those of any other monarch. The rich trade with the Indies, by way of the Cape of Good Hope, diverted from its former track that commerce upon which the prosperity of Venice and Genoa rested.

When Charles V. ascended the throne of Spain in 1517, he had a dominion greater than that of the old Roman Empire. Not only Spain, but also Austria, Naples, and Sicily, the Netherlands and both Americas were under his rule, while two years later he was made Emperor of Germany.

When his son Philip married Mary of England, it seemed as if his dominion would become world-wide; but decay had already set in. The people of the Netherlands began and carried through, in spite of the efforts of Spain, a fierce

struggle for liberty. The people of Germany, stirred up by Martin Luther, showed signs of rebellion. Mary of England died, and Elizabeth, her sister, a strong ruler, took her place.

At this time, too, English seamen came to the front, and daring sailors, Drake, Hawkins, Frobisher, and many others, plundered the Spanish lands in America, and captured the treasure-ships filled with gold and silver, wrung from the natives of the New World.

At length, angry at his losses, Philip resolved to conquer England. Every one knows how the grand fleet, intended to sweep the English from the seas, and to land a conquering army on English soil, was scattered.

After this disaster the power of Spain waned rapidly, and the command of the sea passed into the hands of the English, though daring French sailors, amongst them the famous Jacques Cartier, who sailed up the St. Lawrence River, began now to cross the Atlantic, and to explore the North American coast.

On the western coast of America the Spaniards still had it all their own way; and their ships sailed on exploring voyages as far north as the mouth of the Columbia River.

Sir Humphrey Gilbert, and his half-brother, Sir Walter Raleigh, were the first to form

English colonies in the North American continent, Sir Humphrey sailing to Newfoundland, and Sir Walter in the following year landing in the country he named Virginia, in honour of Queen Elizabeth. It was here, on the banks of the James River, that, in the reign of James I., the first real settlement was made, just a year before the first French settlement was made at Quebec on the St. Lawrence.

In the year 1638 there were six European settlements in North America: the Spanish held Florida; the English cavaliers held Virginia; there was a Swedish colony on the Delaware; a Dutch settlement round the mouth of the Hudson, where New York now stands, and the colony founded by the Pilgrim Fathers still further north, while the French held the banks of the St. Lawrence.

During the reign of Charles II., the command of the sea was boldly claimed by the Dutch, their admiral Van Tromp even sailing into the Thames with a broom at his mast-head, to show that he intended to sweep the British from the ocean.

In the long run, however, Britain prevailed over all rivals, defeating even the French, and in the middle of the eighteenth century was mistress of the American continent, from the Gulf of Mexico to the Arctic Ocean.

During this period, and for many years afterwards, British courage and enterprise caused numerous expeditions to be sent out to explore the frozen seas to the north of the continent, and, if possible, to discover a north-west passage to India. Such men as Frobisher, Davis, Hudson, Baffin, Parry, Franklin, and M'Clintock are only a few of those who gained fame in the northern ocean.

The quarrel with our colonies, which ended in the rise of the United States, lost us a vast country, rapidly increasing in wealth and population, and a keen rival of our own.

During all these years the size and shape, the rigging and equipment of vessels, either for the carriage of goods or for naval warfare, had very much altered; but the mode of propelling was still the same. Tall masts were set up, keyed into the keel of the vessel. Joined to these masts were yards and booms, from which the sails were hung. By so fixing yards and booms that the wind struck the sails at a certain angle, and so placing the helm that the ship could not fall off before the wind, she could be made to speed through the water along a course, as near to the wind as possible.

But, though many of the finest sailing-ships could sail wonderfully near the wind, they could not, of course, make headway directly

against it. They had to reach their port by making a number of "tacks" or "reaches," sails and rudder being altered from time to time in their position, so as to bring the wind sometimes over the starboard bow, and sometimes over the port bow.

A great deal of time was lost over this sort of voyage; yet people, both here and in America, were vastly proud of the splendid clipper ships which ran between New York and Liverpool, and between Britain and India and China.

The "wooden walls" of England are famed in song and story; and if, in the first thirty years of last century, any one had ventured to say that the cloud of canvas, carried by our war-vessels, would ever be replaced by steam-power, he would have been laughed at as a very foolish person.

Towards the close of the eighteenth century, a new way of driving ships was discovered. The trials of Symington with steam paddle-boats, on Scottish lakes and rivers, were followed by Fulton's running such boats upon the Hudson River during the years following 1807, when the *Clermont* began a regular passenger traffic from Albany to New York.

Some five years after this Bell's *Comet* began to ply on the Clyde, but people were

still timid about trusting their lives to such a strange means of conveyance.

Although between this date and 1836 both engines and paddles had been much improved, most of the steamboats were employed upon inland waters, or arms of the sea. Very few had made long ocean trips—indeed, people regarded it as almost tempting Providence to trust property and life to so frail and uncertain a method of navigation.

It was believed, indeed, that steam-vessels were quite unsuited for the stormy waters of the ocean.

Mr. Napier, of Glasgow, was the first to see they might be built to weather the roughest sea; and he started the *Rob Roy* packet between Greenock and Belfast. This was so decided a success that, very shortly afterwards, he had another steam-packet running between Dover and Calais.

Men with money to invest began to fancy there was something in steamers after all, and orders were given for the building of steamers, gradually increasing in size and in the power of their machinery.

While Napier went on extending his lines of packets between Holyhead and Dublin, Liverpool and Greenock, other firms began running steamers across the North Sea into

the Baltic, and even round Portugal into the Mediterranean.

But to dare in a paddle-steamer, depending on its supply of coal, and on its frail machinery, the voyage across the Atlantic was looked on as little better than madness.

It is true that in 1819, the *Savannah*, a vessel of three hundred tons, had crossed from America to England, using sails as well as steam; but this success was considered by many to have been only a happy chance which might not occur again.

In 1838 the British Government asked ship-owners to send in prices for carrying the mails by steamship between England and America. The mails were then carried by fine sailing-packets, which usually took about six weeks in making the passage.

The advertisement came under the notice of Samuel Cunard, who was still engaged in carrying the mails to the Bermudas and other places on the western side of the Atlantic. He had long wished to begin a regular line of steamers across the Atlantic; but the cost of such an enterprise, and the risk of failure, had so far prevented him.

Now, however, if he were certain that the British Government would be one of his regular employers, he need hesitate no longer.

Crossing over to England, he obtained an introduction to Mr. Napier. Napier introduced him to Mr. Burns of Glasgow and Mr. MacIver of Liverpool; and a company was soon formed with a capital of £270,000.

In the meantime two steam-vessels, the *Sirius* and the *Great Western*, had crossed from Britain to New York, arriving at the latter port on the same day, to the delight of the American people; and the owners of the *Great Western* at once applied for the mail contract. Their terms, however, were not considered so good as those offered by Cunard, and the work was given to him.

On the 4th of July, 1840, the first Cunarder, the *Britannia*, set sail from Liverpool, departing amid the cheering of a crowd of people, and reached Boston a fortnight later, thus making what was considered a wonderful passage. Mr. Cunard, who was on board, was greeted as a conquering hero, and received no less than eighteen hundred invitations to dinner, during the first day of his stay in the famous American city.

The *Britannia* was a wooden steamer with paddles and sails, and her speed was about eight knots an hour. Compare this with the *Mauretania's* twenty-four knots, and you will

have some idea of the progress made in steamshipping in the last seventy years.

Charles Dickens, who crossed to America aboard the *Britannia* in 1842, thus describes the saloon:

"A long, narrow apartment, not unlike a gigantic hearse with windows in the sides; having at the upper end a melancholy stove, at which three or four chilly stewards were warming their hands; while, on either side, extending down its whole dreary length, was a long, long table, over which a rack, fixed to the low roof, and stuck full of drinking-glasses and cruet-stands, hinted dismally of rolling seas and heavy weather."

It was just three years after this date when Donald Currie entered the Company's service at Liverpool. There were then three Cunarders, the *Britannia*, the *Arcadia*, and the *Caledonia*; and those three carried all the mails and passengers between Britain and America!

Donald Currie had always been fond of ships, read all the sea-tales he could lay hands upon, and amused himself, as a boy, sailing toy ships on the streams and ponds round Belfast, in the north of Ireland.

At fourteen he began work in a shipping-office in Greenock, and at eighteen went to Liverpool and the Cunard Company.

From the first he showed ability and earnestness, and was soon trusted with important matters. When the repeal in 1849 of the Navigation Laws here and in America—laws which had crippled the trade of both countries—gave to British firms a chance to secure some of the rich trade between America and Europe, Currie was sent to Havre, in France, in order to look after the interests of the Cunard Company.

In a short time he induced some of the French shippers to send their goods to America in British ships—Cunarders, of course, when he was able to manage it — thus beginning that trade between America and France, by way of Liverpool, which has done such service to our shipping industry.

So well did he manage this French business that, in the year 1856, he was put in charge at Liverpool of the whole Cunard concern, his brother being appointed to look after the French interests of the company at Havre.

It was in this year that the first Cunarder built of iron made her maiden trip across the wide Atlantic.

The use of the screw-propeller for paddles was another forward movement of the greatest importance. The principle of the screw had been known to the Chinese for centuries; but

though efforts had been made in Europe to apply it to the driving of ships through the water, none of them had been successful, till Smith in England, and Ericssen in America, hit upon a plan of applying steam-power to it. This was in 1836; but no British war-vessel was fitted with it till the year 1842, when it was fitted to the *Rattler*.

The principle of the screw is very simple. Powerful engines with their boilers and furnaces are placed in the vessel; and the engines turn a long shaft running through a tunnel just above the vessel's keel, and coming out under her stern. On the end is keyed the propeller, consisting of two or more oblique blades, set on the shaft, much after the fashion of the sails of a wind-mill. When the shaft revolves, this screw drives a twisting stream of water astern, and the water makes a forward pressure against the screw. This pressure, transmitted by the screw to the vessel, moves her forward.

Because of its many advantages the screw soon replaced paddles in ocean-going steamers, and especially in war-vessels. The engines were deeper in the ship and more out of the way of the enemy's shot; the propeller was quite under water, and the handiness and seaworthy qualities of the old sailing-ships were equalled, if not surpassed.

From 1856 to 1862, under Sir Donald Currie, the Cunard Company became more successful, adding to the number of its ships, till in 1862 was launched the *China*, the first screw-steamer owned by the company.

Since that date the Cunard Line has always been noted for the size, speed, and comfort of its passenger vessels; its directors have taken advantage of everything that would make the voyage from Britain to America, or from America to Britain, quicker, safer, or pleasanter.

At the present time it owns a fleet of twenty-four splendid steamers, including those ocean greyhounds, the *Lusitania* and the *Mauretania*. It was on board a Cunarder, the *Campania*, that the first number of the first ocean newspaper was published, giving all the latest news as supplied by Marconigrams from the Poldhu station in Cornwall.

In 1862 Sir Donald Currie left the employ of the Cunard Company, and started for himself as an owner of a line of sailing-ships, running from Liverpool and London to the East Indies, by way of the Cape of Good Hope—the Suez Canal was not opened for another seven years, and even had that route been possible, it would not have been so suitable, so speedy, or so cheap for sailing-vessels.

The ships and officers of the Castle Line

became justly famous; for in this new venture Sir Donald worked on the same plan which had helped him to do so well for the Cunard Company. In all his work he was earnest and thorough; whatever he took in hand he did with all his heart.

The steady improvement in steamships and their machinery at last forced Sir Donald to replace his fine sailing-ships with screw-steamers, the officers being moved from one class of ships to the other.

In 1881 the Castle Mail Packet Company was formed to take over the vessels of Donald Currie and Company, carrying passengers and mails to South Africa for many years. Donald Currie, of course, remained head of the firm.

Another company, the Union Steamship Company, had since 1863 been carrying on a regular trade with South Africa, Natal, and East Africa; and in the year 1900 the two companies became one, under the name of the Union-Castle Steamship Line.

This company has nearly forty steamers running between Southampton and South Africa, with passengers and mails, the finest vessels of the fleet, such as the *Kenilworth Castle*, the *Armadale Castle*, and others nearly as big and as swift, leaving Southampton regularly in their turn every Saturday morning.

For his services in connection with South African affairs, the Queen in 1875 created Sir Donald a Knight Commander of St. Michael and St. George (K.C.M.G.).

One fact amongst many others may be related to show how helpful in time of need a man like Sir Donald may be. After the disaster at Isandlwana in January, 1879, when a whole British army corps was destroyed by the Zulus, twelve hundred soldiers were shut in at Ekowe by a strong force of Zulu warriors. Unless help and provisions came, they would have to sally out, and cut their way through to the river Tugela, twenty miles away, where the main British force was encamped.

When news of the disaster reached home, the Government set to work to secure two steamers to carry troops to Natal. It was also most important that directions should be sent without delay to Sir Bartle Frere, in command of the troops in Natal.

At that time the telegraph cable reached only to Cape Verde, about fifteen days' sail from Cape Town. One of the Castle Liners was on her way to the Cape, and was on that date expected to call at Madeira. With the approval of the Government, Sir Donald telegraphed to her captain, telling him to stop at Cape Verde for instructions.

Between Madeira and Cape Verde was three days' sail. In that time the Government decided upon their best course, and instructions were telegraphed to Cape Verde and carried by the steamer to Cape Town. This saved a week; and the message reached Sir Bartle Frere in time for him to stop the sallying out of the garrison. Thus was prevented what might have been another disaster.

Since that time Sir Donald Currie has been given many difficult missions to the Boer peoples of South Africa, and he has taken the greatest interest in that country. As a gifted lecturer on all matters relating to the sea, and to the ships which sail upon it, he is well known; and he has many pleasant memories of pleasant hours spent with famous people he has carried as passengers on his ships.

On one occasion, when Lord Tennyson and Mr. Gladstone were passengers on the *Pembroke Castle*, the vessel entered the harbour of Copenhagen, and was saluted by the manning of the yards of all the foreign warships off there. At a banquet held on board there were present twenty-nine Royal persons, including the sovereigns of Russia, Denmark, and Greece, with the Princess of Wales, our present Queen Alexandra.

The improvement of the marine steam-engine has occupied the thoughts of some of the finest

minds of our day. One drawback to the employment of steam-vessels for long voyages was the large amount of coal which had to be carried, taking up valuable room which otherwise might have been given to cargo.

One improvement needed, therefore, was the lessening of the amount of fuel. At the present time, though the coal used on our largest and fastest steamers is enormous, the speed attained and the vast amount of cargo carried are most satisfactory, and the vessels can be made to pay a handsome profit to their owners.

One of the chief improvements was the invention of the compound marine-engine. In this engine the steam, after doing work in one cylinder passes into a larger second cylinder instead of going direct to the condenser. By this means the amount of work done by the same amount of steam is much increased.

A further advance was made when triple- and quadruple-expansion engines were invented. In these engines the steam passes through three or four cylinders before reaching the condenser, in each of them doing a certain amount of useful work.

By the invention of better methods of building boilers, and especially by the employment of tubular boilers, the pressure of the steam is also greatly increased.

But a greater development was yet to come. During the Naval Review at Spithead in 1897, a small boat entered the long reaches of water between the war vessels. As this was strictly forbidden, the swift steam picket-boats of the navy set out to turn her back. But do what they would, they could not get near her.

At a high speed—nearly thirty-five knots an hour—she raced along, defying them all. This boat was the *Turbinia*, built on the Tyne to the order and on the plans drawn by the Honourable Charles Parsons, and the first boat fitted with the wonderful steam turbine which he had invented.

The naval authorities lost no time in asking Mr. Parsons to supply the Government with a similar boat; for the usefulness of the torpedo-boat destroyers and despatch boats of the navy depends very much upon their speed.

With turbine-engines steam is used directly for driving the propeller-shaft, without cylinders and pistons; and it is reckoned there is a great saving in coal, in weight, and in cost, while the speed obtained is much higher.

They have been placed in all the chief passenger ships built during the last year or two, and in some of our finest warships.

The *Lusitania* and the *Mauretania*, mentioned

already, are fitted with these engines, and have made record passages across the Atlantic.

The *Mauretania*, which was built upon the Tyne, is slightly the larger of the two, and is in many ways one of the most wonderful ships the world has ever seen.

Seven hundred and ninety feet in extreme length, eighty-eight feet in breadth, and sixty feet six in depth, she carries seven thousand six hundred tons more than the famous *Great Eastern*, which was eighty feet shorter. Her gross tonnage is nearly thirty-two thousand—twenty-seven or twenty-eight times as much as the tonnage of the first Cunarder.

Amidships there are seven decks—the lower, main, upper, shelter, promenade, boat, and sun decks; and at the two ends there are two extra decks, the orlop and the lower orlop—or nine decks in all.

Her engines work four propellers, which drive her through the water at a rate of over twenty-seven knots an hour, equal to nearly thirty-one and a half land miles.

The ship is so large and so beautifully fitted that she may well be called a floating palace. She and her sister ship, the *Lusitania*, give half as much again of light and air and deck-space per passenger more than any other liner afloat.

The *Mauretania* can carry five hundred and

pay a very large interest upon the money that had been borrowed.

The fellaheen, as the country folk are called, had not the slightest notion of the laws of health. Their water-ways were used as sinks, into which might be thrown any kind of rubbish, dead animals, and household filth. The streets never being cleaned were filthy to walk through. In the cities there were thousands of houses consisting of one room only, built of mud, and affording shelter for asses, poultry, and other domestic animals.

It is only fair to these poor fellaheen to say that they have for ages been most unjustly treated by their Turkish rulers. At any time they could be dragged away from their work and from their families, and compelled to labour for the Khedive, not even food being supplied to them. This forced, unpaid labour was known as the "corvée"; and it is one of the results of British rule that the corvée has entirely disappeared, any labour needed being paid for at a fair rate.

The whole fertility of Egypt depends upon the annual rising of the Nile, which begins in June, and generally reaches its greatest height in October, gradually sinking afterwards till in May it is at its lowest level. This rising of the waters is caused by the deluge of rain which

falls, during the spring of each year, on the mountains of Abyssinia; and the mighty floods rushing down the Nile carry with them vast quantities of rich, fertile soil, washed from the mountain sides.

Instead of being allowed to pour into the Mediterranean, this flood water is conveyed in many canals to the fields, covering them with a thick coating of mud. The villages in which the fellaheen live are built upon mounds, rising above the water-covered land around them, appearing like palm-crowned islands in a vast sea. Here and there are raised banks dividing the fields, or serving to keep in the water; and along these banks men and asses, or even camels, may be seen travelling from one village to another.

When the flood subsides in late October or November, nothing is to be seen between the villages but bare plains of black mud, on which the fellaheen are busily at work, scratching the ground with their rude ploughs, and dropping in the seed.

But, when Britain became the guiding hand in 1883, the irrigation works were in a poor state. Most of the water was allowed to pass to the sea, instead of being stored up; and the canals were badly made and kept.

Egypt has been called "the land watered by

the foot," because, in many cases, the pressure of the foot upon the soft earth, forming the bank of the canal, made a passage for its brimming waters to the fields on each side.

In his account of "Irrigation in Lower Egypt," Sir William Willcocks pointed out some of the problems to be solved in connection with that work.

The dams or "barrages" as they are called, built across the two chief streams into which the Nile divides some distance below Cairo, and intended to secure a constant high-water level during summer, had to be strengthened and secured. This monster weir, or open dam, stretching right across the Nile at the point where the two streams spring off, the one to reach the sea at Damietta, and the other at Rosetta, had been finished twenty years before by a Frenchman, Mougel Bey.

It was intended to hold up the water at low Nile, to a height of over fourteen feet, turning it into the canals, which covered the whole delta like a network. The barrage, however, built upon a foundation of sand and river mud, had been undermined by the water, which scoured out the sand from beneath it.

So useless had it been thought by the Ministry of Public Works at Cairo, that a costly scheme of pumping was about to be tried, in order to

supply the cotton crops of the delta with the water needed.

At this time Colonel Scott Moncrieff and his staff of Indian engineers came on the scene; and the work of strengthening the barrage was given to Sir William Willcocks—or, as he then was, Mr. William Willcocks.

He was so successful that the barrage was made capable, not only of giving all the water required, but of delivering it at a level so much higher than before that many fields, for which water had had to be raised by means of pumps and water-wheels, were now watered without their aid.

The foundations of the barrage were made so strong that no further fear was felt as to its safety, and flood-gates were fitted to the arches on the Damietta side, where they had been entirely wanting.

This barrage consists of two massive bridges, measuring together nearly two-thirds of a mile in length, set across the Nile at the apex of the delta, about fifteen miles north of Cairo. When the river is in flood, the gates are raised; and the water, with its rich burden of silt, flows freely through the arches. When the river is low, the gates are dropped, and the water is held up and turned into three main canals, from which Lower Egypt is irrigated.

Mr. Willcocks found the barrage so badly looked after that the woodwork upon it was in a state of decay, and all the iron was eaten with rust.

To carry out his plans took six years, and cost nearly half a million of money; but the benefit to the country during each of those six years was reckoned at three-quarters of a million; and since the completion of the work the annual benefit has vastly increased.

The strengthening of the foundations was done in a most remarkable way. Half of each barrage was taken at a time, so that four years were needed to finish this part of the work. Twenty arches were surrounded with a dam, and the water was pumped out, leaving the floor bare.

Over this floor was spread a layer of Portland cement, four, and in some places six feet thick; and this was covered with a dressing of heavy stone. Eighty-five feet higher up the river a line of sheet piling, sixteen feet in depth, was carried right across the river. By these means the water was prevented from getting under the foundations. In many other ways the barrage was made firm, and is at the present time doing splendid work.

One of the chief difficulties was that, during the whole time, enough water for irrigation purposes had to be held up, for upon that water depended the greater portion of the crops of Lower Egypt.

"It was like mending a watch and never stopping the works," said Colonel Scott Moncrieff.

This, however, was only one of the problems. Another was the making of escapes and flood canals, so that in summer the fields might be watered from summer canals, and during high Nile from the flood canals. By this means Mr. Willcocks thought he might prevent the deposit of mud and slime in the canals.

This yearly deposit of mud in the canals had been one of the chief reasons for the corvée. The mud had to be dug out while it was soft, and in such good time that the canal was clear before the next flood; and for this labour men were forced to leave their own fields, just when they were most needed for the setting of seed. Hundreds of them, half-naked and sweating, jostled each other in the narrow cutting, carrying the mud in wide baskets up the sides of the canal.

Much of this labour was gradually replaced by the use of dredgers; and much was done away with through the good work of the British engineers, who favoured the employment of paid labour instead of the corvée.

The third problem mentioned by Mr. Willcocks was the obtaining of a flood supply in the canals, as early in the year as possible. This meant the building of huge reservoirs, the

water from which would pour into the canals at low Nile. Of his plan for meeting this need, mention will be made further on.

The fourth problem was the draining of the lowlands, and making them fertile again by basin irrigation.

In Egypt there are two kinds of irrigation—basin and perennial. In the former the flood-water is led into canals, from which it is allowed to overflow the land, the fields being surrounded by earthen banks to keep it in. Here it deposits its rich mud, and after a time is allowed to escape, leaving the land ready for the farmers. But, as the Nile is in flood only once in the year, these "basins," as they are called, can be flooded once only in that time, thus giving one annual crop.

By the second way the water is led even from low Nile, or from reservoirs, whenever it is needed; and, in some of the more favoured places, as many as three crops can be got from the same land every year. By this means a tract of country becomes vastly more valuable than if it has basin irrigation only.

Much of the land in Lower Egypt, which had formerly been so wonderfully fertile, was now water-logged and sour. Long ages of neglect had brought about a state of things which was a disgrace to any nation. Some of

the land was so damp in December that the grain simply rotted in it. The lazy fellaheen, working often only when forced, had allowed the drainage canals to become silted up with mud, and in some places had even thought it a good plan to keep the water standing in them as long as possible, and then letting it back upon their fields.

They had to be taught by our engineers the difference between irrigation and drainage canals, and forced to keep the drainage canals open and in good working order, letting in during flood-time just the amount of water needed, and no more.

Egypt has several inland lakes of fair size, round the shores of some of which the land is cultivated; but many of them are surrounded by salt plains. To make these plains fruitful again it is only needful to irrigate them, and to provide for proper drainage, so that the hurtful salts may be carried away. In some countries this would have been done ages ago by rain, but in Egypt there is no rainfall, the land depending for water entirely upon its river.

Mr. Willcocks also pointed out that the Nile dikes must be able to resist the tremendous pressure of the river when in flood. The ruin caused by a breach in the bank during flood-time can hardly be estimated, as wide tracts

of country are lower even than the level of the river.

Willcocks and his fellow-workers set to with a will, making the mud banks broader and stronger, and, in places where danger was to be expected, using a great deal of stone.

The last and greatest problem was the regulation of the water-supply. It was felt that, though the barrages across the Nile where the Rosetta and Damietta streams sprang off, gave a supply of water to Lower Egypt, much of the valuable flood was still wasted, and allowed to run away through Upper Egypt.

In Upper and Middle Egypt the land could be watered only by "basin" irrigation, giving, in spite of its fertility, but one crop a year. It was felt that, if the water could be held up at some point far distant from the sea, the whole of this land might in course of time be made fruitful.

The place, which seemed to have been intended by nature for the building of a great barrage or dam, was at Assouan, seven hundred and thirty miles up the river from the Mediterranean, and five hundred and fifty from the city of Cairo.

At this place the river rushes down a series of cataracts, many rocky islets and smaller masses of stone thrusting their heads above the stream. Between Assouan and Cairo, along

both banks of the river, are the remains of cities so ancient, and yet so well and strongly built, that travellers are lost in wonder as they gaze upon them.

Here Willcocks thought the barrage ought to be built; and he carefully drew up plans for one of the most wonderful feats the world has known. The work was so tremendous and the cost so vast that people may be excused for asking if it could pay.

But in Willcocks the Egyptian Government had secured a man, who not only knew the value of all the land in Upper and Middle Egypt, but who was able to figure out the increase in value which would occur, when the work he had planned was finished.

This knowledge he had gained during the years he had been Director-General of the ten commissions, appointed by the Government, to value the whole of the land of Egypt, so that the land-tax might be placed fairly and justly on the farmers.

So well did he carry out this task, that, years afterwards, the mention of his name worked like a charm among the fellaheen. One writer tells of a pleasant experience in a part of Egypt, far out of the beaten track, and seldom visited by travellers. He was an artist, and landed at sunset close to a village near a pyramid which

he wished to sketch. His servant, who had formerly been employed by Willcocks, went ahead to prepare the people of the village for his master's visit.

When the artist drew nigh, he was astonished to see the head-men coming in their finest clothes to meet him. They gave him a hearty welcome, some capital coffee, and an invitation to stay for the night.

On asking his servant why he had been received so kindly, he learned that the man had said he was a friend of 'Cocks. "The sheikh very fond of 'Cocks," he said; "he so fair, he like him."

Mr. Willcocks had planned in all seven reservoirs, two of which, the one at Assouan, and a second at Assiout, midway between Assouan and Cairo, he specially recommended.

The Government had some difficulty in obtaining the money to begin, but at last it was forthcoming, and the mighty task was begun; the plan followed being that of Mr. Willcocks', with one important difference.

This was in the height of the dam at Assouan. Willcocks had intended that it should be nearly twenty feet higher than it is, thus holding up another thousand million cubic metres of water. This added amount of water would have enabled the engineers to irrigate another half-million

acres, adding fifteen million pounds to the value of the land.

Why was not this plan carried out, you will ask? Well, it happens that the raising of the level of the water by another twenty feet, would have covered the island of Philæ, the most beautiful spot in Egypt.

The island is only about four hundred yards long, but it is crowded with the remains of Egyptian temples, most wonderfully preserved in the rainless air. By the Egyptians it was known as the "Sacred Isle"; and many students of past peoples and their monuments spoke so strongly against its destruction that, much to the disgust of the engineers, the Egyptian Government gave way, and reduced the height of the dam.

There is no doubt that at an early date the first plan will have to be carried out, as the supply of water afforded by the reservoir, vast as it is, has already proved less than the farmers desire.

The barrage is a granite dam, one and a quarter mile in length, founded upon the granite ridge which forms the crest of the cataract. Its width at the top is about twenty-three feet, and at the bottom eighty-one feet. It contains a million tons of masonry; and its height above the river bed is one hundred and twenty-five feet, though, in some places, where

sound rock was found, its height is rather less than this. The surface of the water in the reservoir above it is sixty-seven feet above the level of the water in the river below it.

The dam is flung right across the Nile from bank to bank; and river-boats and steamers, wishing to pass it, have to climb or descend by a ladder of four locks.

When the Nile is in flood, one hundred and forty sluice-gates, each twenty-three feet high by six feet six in width, are opened to allow the water to pass freely. These sluice-gates are worked up or down by winches on the top of the dam, where runs a roadway fourteen feet wide.

The cost of this dam was two and a half million pounds, and it was worth every penny of the money. The actual building was taken in hand by Messrs. Aird, the famous contractors.

Not content with this success, Sir William Willcocks has made further plans for bringing more water to Egypt. He advises the raising of the Assouan barrage to the height first intended, and the forming of a huge lake about fifty miles to the south-west of Cairo, where there is a big hollow in the land. This lake would be filled by a canal taking off above the Assiout barrage, and would form a reservoir, which, working in turn with the one at Assouan,

would give to Egypt all the water she could ever need.

Water has been called the life-blood of Egypt; and there can be no doubt that the splendid work done by such men as Sir William Willcocks, has brought back to the ancient country some of its old-time wealth and prosperity.

The value of goods imported into Egypt is now more than three times as great as in 1883, when Britain took over the government of the country, while the exports have doubled. The fellaheen are free from the terrible corvée; they live in security from foreign enemy or domestic tyrant, their property and money are safe, their taxes are much lighter, and their health and education are being attended to most carefully. In other words, the nation, which had seemed to be altogether dying, has taken a fresh lease of life.

In the ages to come, when the foreign tourist visits the ancient land of the Pharaohs, he will gaze in wonder, not only at the mighty pyramids raised by kings of old to their own glory, or at the splendid temples erected with such care and skill to the glory of gods whose worship ceased long ages ago, but also at the monuments of engineering skill, raised for the benefit of the inhabitants of the land, by the northern race who came to the rescue, when the country and the people seemed altogether doomed.

VI.—Thomas Alva Edison.

In the little town of Milan, in Ohio, there was born in the year 1847, Thomas Alva Edison, towards whom, in years to come, the eyes of all the world were to turn, in wonder and delight, at the marvellous things he was doing.

Few men have left so deep a mark upon human affairs; and yet few have had a more humble beginning. Very early indeed, having to help towards the keep of the family, he became a sort of train merchant, buying papers and fruit and toys at Detroit, and selling them on the train itself, or upon the platforms of the stations between that city and Port Huron.

Even in this he was successful, and had at one time several assistants. He made a great hit once, by getting the telegraph operators, at the stations along the line, to send word in advance of some news for which the people were waiting, and which the papers he was bringing along gave a full account. Some of these papers he sold to eager buyers at a shilling each, though their ordinary price was no more than twopence-halfpenny.

This deal turned his active mind to the profit that could be made out of printing, and out of the telegraph. He set to work at once with an old printing-machine and a lot of old type, and produced the *Grand Trunk Herald*, a single news-sheet, which was printed and sold upon the train, the printing-office being a corner of the baggage-van.

He sold a good number of copies of his paper, and even produced another which was called *Paul Pry*; but this was too personal to please all its readers, and, after Edison had been thrown into the river by a man of whom he had made fun, he decided to give up printing.

All this time, however, he was busy with experiments, chiefly in chemistry; and one day had the misfortune to upset his chemicals in the corner of the baggage-van, and thus nearly set the train on fire. This was too much for the guard, who pushed him out of the van, boxing his ears as he did so with such force that he has always since been more or less deaf.

The electric telegraph was always very interesting to Edison, and after his first newspaper success he thought more of it than ever. Gradually it took up nearly all his thought, and at last he became an operator, or, as we should call it, telegraph clerk.

As tne years went on, it became more and more evident that Edison was no ordinary lad; though his fondness for experiment lost him more than one good place, and got him into trouble in many ways.

Right through his boyhood and early manhood, however, he showed many signs of the perseverance which has helped him so much in his wonderful discoveries. He never drank, or wasted his time in idleness or in profitless games—his amusement was always some other form of work.

While he was an operator he found out new powers of the electric telegraph, showing how one and the same wire might be made to carry two or more messages, some going one way and some the other.

For long ages he will be remembered as the man who "kept the path to the Patent Office hot with his footsteps;" for his brain seemed full of ideas jostling each other for first place. The electric telegraph, the electric light, the telephone, electric traction, the phonograph, the microphone, and the bioscope were only some of the fields in which he worked—his clever inventions number altogether more than one thousand.

It is interesting to trace the steps by which any important truth has been discovered, or

by which any great force has been made to do work for mankind; and this is especially true with regard to the electric telegraph.

As early as the year 1819, it was discovered by a Dane, named Œrsted, that, if an electric current be passed through a wire which runs near a magnetic needle and parallel to it, the needle will swing either to the right or to the left, according to the direction of the current.

One wire, he found, had not much effect upon the needle; but if the needle were surrounded with a coil of insulated wires, it would go much farther to left or right. Insulated wires are those which rest upon some substance, such as glass or china, which will not permit the current to leave the wire, as it would do, if the wire were supported upon such substances as metal of any kind, or even wood or stone.

It almost seemed as if the wire became magnetic, when the current passed through it. At any rate, it showed there was some relationship between magnetism and electricity.

We do not seem to have come much nearer the telegraph yet, do we? But this was, of course, only the first little step.

A short time afterwards, a Frenchman, named Ampère, found that, if an electric

current were passed through a coil of wire surrounding a piece of soft iron, the iron became a magnet—that is, it would attract steel and iron—and a magnet it remained as long as the current continued. But, as soon as the current was withdrawn, the iron ceased to have any power.

Possibly it would puzzle you to invent the telegraph from these two pieces of information, and yet, upon these two facts, the electric telegraph depends.

Suppose you get a long wire of copper—almost any other metal would do, but copper is best for many reasons—a wire as long as you like; you know that an electric current will travel from one end to the other in almost no time at all. At each end of your wire fix a coil surrounding a piece of soft iron, one end of the coil being fastened to your long wire, and the other going down to the ground.

Just over this electro-magnet, as it is called, suspend another piece of iron by means of a strong spring. If an electric current is made to pass through the coil, the iron will become a magnet, and will pull down the piece above it, which is called the armature. If, then, you have a battery at one end, so placed that with a key you can send a current

from it, for as long or as short a time as you like, along the wire, you can make the armature at the other end do just as you please. If you send the current for a long time, the armature will stay down a long time, and if you send only a brief current, the spring will pull up the armature almost at once.

It was from thinking over these two simple facts that Sir Charles Wheatstone and William F. Cooke invented the first telegraph in 1837.

Invention has followed invention, and discovery has trodden upon the heels of discovery from 1837 to the present time. Some of them were the work of the grand old man who recently passed from among us—Lord Kelvin, or, as he used to be called, Sir William Thompson—but a large number were made by Edison.

The telephone, as you know, is the instrument in which an electric current conveys along a wire the sounds of a speaker's voice. Sound is the impression made upon our brains by waves in the air, which strike upon our ear-drums. These waves are set in motion by anything which vibrates; and they, in their turn, can make anything vibrate upon which they strike. Vibrations are carried through bodies of many kinds. A wire will carry them, and give them off to the air at the other end.

Reiss, of Frankfort in Germany, discovered,

in 1861, that musical sounds could be sent along an electric wire to a much longer distance than they could travel without the help of electricity; but it was not until 1876 that the first telephone, able to carry ordinary speech, was invented by Professor Graham Bell, of America.

In the same year Edison invented his "carbon transmitter," without which Bell's telephone would have been much less useful. This instrument increased to a wonderful degree the sounds sent along the wire. It is really the microphone—the magnifier of little sounds.

Edison had found out that sound, when passed from one piece of carbon to another, became increased in volume. In making his microphone, he placed first against a sort of little drum, a carbon button. Against this he rested a little carbon stick, and against this a second, and so on to another drum.

The increase in the sound passing through all these pieces of carbon is astonishing. The tramp of a fly is like that of an army—the gentle sweeping of a camel-hair pencil resembles a wild storm in a forest.

This discovery he applied to the telephone with splendid results. Other inventions of his have further increased the usefulness of the instrument.

Long before this time, however, Edison had

become a wealthy man, and a large employer of labour. Some firms, indeed, paid him a handsome annual salary, to keep them informed of any invention which might be useful to them in their business.

He was always aware, also, that, though an inventor may get very good pay for his inventions, the man who makes the money out of them is the man who manufactures and sells the instruments. Knowing this, he was careful to keep in his own hands many of his best inventions; and, at Newark, within easy distance of New York, he set up a fine workshop, and employed three hundred men.

He was at this time only twenty-six, but already known nearly all over the world. His workmen loved and respected him—for, not only had he finer brains than theirs, but he was a better workman than any of them. They would do anything for him, even working for nights without sleep, when some important task had to be finished.

One one occasion, when some machines refused to work, he had the whole batch carried to an upper floor to find out what was wrong with them, taking with him the pick of his workmen. Locking the door, he turned round and said:

"Now, you fellows, I've locked the door,

and you'll have to stay till this jôb is done." And stay they did, till the flaw was discovered, and the machines were put right.

Some idea of the huge sums, which Edison was receiving for his inventions and manufactures, may be grasped from the fact that, in 1876, the year in which Bell and he enabled persons to speak to each other at long distances by means of the telephone, he began building at Menlo Park, twenty-four miles from New York, a most complete workshop. Twenty thousand pounds fitted up only the part devoted to experiments. There was a fine library, there were huge machines and motors, and everything that the wit of man could think of, to help in the work to be done.

And wonderful work was done there by Edison and his staff of workers. People used to speak of him as the "Wizard of Menlo Park"; and crowds of them at first tried to call upon him and see him at work, until they learned that no one was admitted except upon the most urgent business.

One of the wonders turned out from Menlo Park was the phonograph, the instrument with the power to reproduce sounds of which it has taken a record.

The idea of keeping a record of the human voice has appealed to people in all countries

and all ages, and some of our fairy-tales are hung upon it. Most of you will remember the story of the servant of the king who had asses' ears. This man had discovered it by accident, as the king always kept them carefully hidden, and he knew that if he breathed a word to any one, he would be put to death. The secret, however, was too great a burden, and he used to ease his mind by going down to the river-side, where no one could hear him, and saying over and over to the reeds at the edge of the water, "The king has asses' ears."

Now, the reeds kept a record of the words and repeated them, and in this way the king's secret became known to all his subjects.

There is another Chinese fairy-tale of a king who spoke into a bamboo, closed at one end, some very good advice to his son, who would become king after him. He left orders that this tube, which had been carefully sealed, was not to be opened till a certain number of years after his death.

When the young man became king he ruled very badly, chiefly because he was too fond of pleasure, and of having his own way; and the kingdom sank rapidly into a terrible state of confusion.

Things were at their worst, when the time arrived for the opening of the tube, and the

son listened with awe to the voice of his father. The old king must have been a good judge of character, for his words were just suited to the case of his son.

Such an impression did this voice from the beloved dead make upon the new king that he reformed his habits, and by attention to his duty made his country once more prosperous and happy.

But, in spite of these fairy-tales, the phonograph was not invented till 1876; and then it was, in a sense, the result of a pin-prick.

While busy with the telephone, Edison was one day working with a small cylinder, upon which a sharp point would make marks like those of the telegraphic alphabet. In trying to adapt this to the telephone he was speaking into the mouth of the instrument, when the vibration caused by his voice sent the sharp point into his finger.

This would have meant little to an ordinary man, but to Edison it pointed the way to a dazzling invention.

"If," he said, "the vibrations are powerful enough to push the needle into my finger, they are strong enough to make marks with the needle upon some properly-prepared surface; and there is no reason why these marks should not give back the sounds that made them."

Getting a strip of telegraph paper, he placed it so that it should run under the needle while he shouted "Halloo! Halloo!" into the mouth of the telephone.

Then, making the paper travel back again under the point, he was delighted to hear a faint "Halloo! halloo!" in reply. He knew now that he was upon the eve of one of the most marvellous discoveries of all time, and he set to work in earnest.

After trying many different substances upon which to make the record, Edison at last produced a machine which would, he believed, do what he expected.

His assistant, Kreuzi, to whose careful hands he had entrusted the making of this, the first phonograph, stood by smiling as he spoke into it, expecting no result.

But, when Edison moved the cylinder in the opposite direction, and the machine began to talk, Kreuzi almost fell down in his sudden fright. Edison himself confessed that he felt rather alarmed.

From this beginning has sprung the mighty industry in phonographs and gramophones, which employs thousands of men and women, by which we can preserve the voices of the most famous singers, and the notes of the finest musicians of our time, to say nothing

of the living words and tones of great speakers and statesmen.

Toys of all kinds, talking dolls, bleating sheep, and barking dogs have been made to delight the hearts of the children. Each has a little phonograph hidden somewhere about it, giving out the real sounds of which they are a record.

The progress of mankind has often been spoken of as the result of man's contest with the forces of nature. One by one he has conquered them, and made them do his bidding—though sometimes they break loose and take a terrible revenge.

Fire and wind and water, steam and gas and electricity have been harnessed to man's machines, and made to do his work.

Fire has warmed him and cooked his food, it has softened or melted the metal of which he wished to fashion his tools and arms and ornaments; and, during the last century, it has turned water into the steam with which he desired to drive his machines.

Water has also been pressed into service. It has turned the huge water-wheels, upon which depended the usefulness of many mills of various kinds; it has been made to raise vast weights; and along with fire has given that mighty power—steam.

For centuries men depended upon the wind—

currents in the air—to send their ships on their courses over the sea; it has driven their windmills, and so pumped water for them, or ground their flour.

The gas driven from coal by heat has been used for lighting our houses and streets, and for driving some of our machines.

But, almost unknown to our forefathers, there was, in their days and in the old time before them, a mightier agent than any yet mentioned. They saw its terrible power in the lightning's flash, and heard it in the roll of the thunder, but of itself they knew little or nothing. To have spoken of catching this force, compelling it to run in appointed channels, and to do special work, would have seemed to them mere madness.

And yet this giant power has been made man's servant. It has been made to light his streets and houses, to bear his messages, and to carry his loads—to so many uses, indeed, has electricity been put that even to name them would take more space than can be afforded in this book.

In spite of this, however, we cannot say what electricity is. We can call it up at will, and make it do our work, but as to its real nature we are still in the dark.

Many men, long before the time of Edison,

had seen that it ought to be possible to harness electricity—to make it, that is to say, a motive force—but no satisfactory plan of doing so had been found.

Hundreds of years before, William Gilbert, a learned physician who lived at the end of the sixteenth century, had discovered that iron heated to redness cannot be attracted by even the most powerful magnet. Working upon this idea Edison built his first motor.

In this motor an iron bar is placed, so that it swings on a pivot close to a strong electro-magnet. The bar, being first heated and then cooled, is attracted to the magnet when cool, but falls away from it when heated. If the heating and cooling go on regularly, the bar spins round on its pivot, and by means of a fly-wheel and belt this motion can be passed on to the machines.

Where electricity is wanted in quantity and force, a dynamo is generally used, a machine, that is, where electricity is caused by friction or rubbing. A steam or gas engine usually works this dynamo; but the electricity it produces can work engines vastly more powerful than the steam-engine which calls it into being, and that power can be taken by means of wires to the place where it is needed.

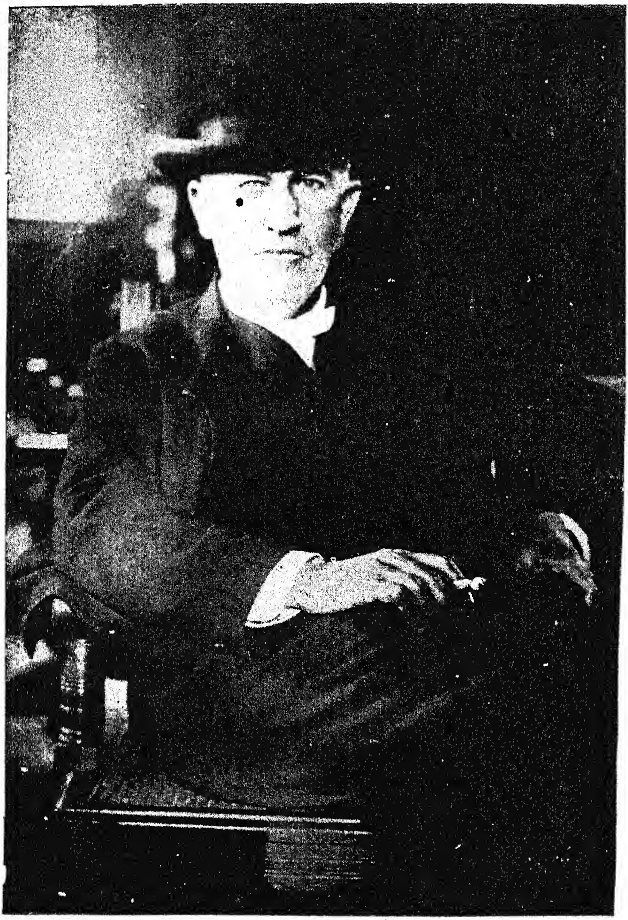

Photo. W. B. Northrop, London.

M W.W.

Thomas Alva Edison.

Edison spent much thought on the making of electric motors; but the problem he most wished to solve was the use of this power for the driving of locomotive engines.

Being so used to seeing steam-engines on our railways we sometimes forget that, wonderful and useful though they are, they have many drawbacks. The steam to work them has to be made, as they travel, upon the engines themselves; so that a heavy load of coal and water must be carried, while the smoke and soot from the furnace are distributed over the landscape. In the case of electricity the power can be carried by wires from the station to the engine.

Edison was not the only person bending all his strength of mind to solve the problem of electric traction. When he had finally settled the difficulty, and had an engine at his works at Menlo Park which could run at the rate of forty miles an hour, some of his rivals put in a claim to the right of being regarded as the first inventor. One claim was that of Mr. Field, who proved that, working altogether by himself, without any help from Edison's ideas, he also had solved the problem, and could drive a locomotive by electricity. Edison admitted Mr. Field's claim, and entered into partnership with him.

From this small beginning, the system of electric tramcars, which has made moving from place to place so much easier and cheaper, has grown. Even the railway companies, in spite of the vast sums that their steam-engines have cost, are beginning to run electric cars on some parts of their lines; and it is probable that, in the near future, a steam-engine will be looked on as an interesting relic of the days when people knew no better.

Edison's grandest triumph, however, was the invention of the electric lamp.

As the world grows older, and people spend more and more of the hours of darkness in work or play, so the need for some light which will take the place of the sun's rays becomes much greater.

In the first ages of the earth's history, when folk hunted or worked while it was light, and slept while it was dark, no other light was asked for—or, if upon occasion a way had to be found through strange paths at night, a blazing pine-knot gave all that was needed.

When people learned to read and to write, and to do fine needle-work, however, they often wished to extend the working hours; and rush-candles, tallow dips, candles of wax, and lamps of various kinds followed one another slowly through the ages.

Then, about the end of the eighteenth century,

William Murdoch invented a method of burning coal-gas with safety in either street or house, and a long step forward had been taken.

Long before this, Sir Humphrey Davy had found out the electric light, but to produce it he needed a battery of two thousand cells, and the cost was enormous. It was the arc-light which he invented—the light caused by the electric current springing across the gap between two pencils of carbon, taking with it particles of carbon which are raised to white heat in the process.

Wonderful though the result was of Sir Humphrey's experiment, he would have been a bold man who would have tried to light London by that method. One of the weak points about it was that the carbon of one pencil wore away so rapidly that, in a short time, the gap was too wide for the current to leap over, and the lamp went out.

Not till 1834 was another serious attempt made to produce an electric light; but in that year Professor Dumas showed in Paris an arc-light, the cost of which worked out at about a guinea a minute.

In 1844, another Frenchman, named Foucault, made an attempt, and, by using harder pencils, was able to delight the Parisians by lighting up one of their finest squares.

It had been found that certain substances resisted the passage of a current of electricity through them, getting quite hot if the current persisted in passing. Fine wires of silver, platinum, and other metals could be raised to white heat, while carbon, though it quickly burned away, gave out a brilliant light in doing so—but it did not melt as the metals did.

This was about as far as the problem of electric lighting had reached, when Edison took it up in 1877. He found the subject a very difficult one. The only substance to resist the electric current enough to turn white hot without melting seemed to be carbon. You know what carbon is—that substance of which soot and charcoal and coal and wood and starch and fat are mainly made up, and which is found nearly pure in graphite and the diamond.

But this stuff is so brittle and soft, and the filament, as it is called, of which the loop has to be made is so thin and frail that the slightest jolt seemed enough to destroy it. Then carbon cannot be made white hot in air without its burning away.

Still, Edison resolved to try. He seized first upon the fact that carbon cannot burn away without air, even when made white hot; and he set about making a number of glass bulbs,

from which all air could be drawn, as soon as the filament was fixed in them.

He and his friend and fellow-worker, Charles Batchelor, then started making filaments of carbon. They took some tough cotton thread, cut a groove of the shape needed in a plate of nickle, placed the thread in the groove, and heated the whole with a covering of powdered charcoal, in a special furnace.

For five hours they cooked their thread, and then tried to lift it—but it fell to pieces. They altered some of the arrangements, and tried again with the same result. Hour after hour they toiled on, and, at last, after two days and nights of sleepless labour lifted a filament without breaking it. Batchelor was just finishing fixing it in one of the bulbs, when it fell to pieces in his hands.

"Look here, Batchelor," said Edison briskly, "we'll make a lamp before we sleep, or die in the attempt."

Two more nights and the day between passed, and yet the weary men went on with their task, making filament after filament, all of which fell to pieces.

On the morning of the fourth day, a perfect filament was made and fitted to the wires. Batchelor was carrying it to the glass-blowers' workshop to have a bulb blown to fit it, when

a puff of wind shook it in his hands, and reduced it to powder.

"Edison," said poor Batchelor, worn out and in deep despair, "it's gone — broken by the wind. I'm sick, I'm disgusted."

Back to work they went again, however, and by the next morning had made a complete lamp which gave a soft but beautiful light. Only then did they allow themselves to lie down, and to take the sleep so badly needed.

Success had crowned their efforts, and an incandescent electric lamp had certainly been made—but the lamp was as yet very far from being perfect.

In his search for a tough vegetable fibre of which to make a good filament, Edison sent trusty messengers to South America, to India and Ceylon, to China and Japan, and to many other countries where such a fibre was likely to be found. These men travelled into some of the most dangerous parts of the earth, spending large sums of money, and risking their lives from fever, from wild animals, and from savage men. One did find a suitable fibre in China, but, by that time, Edison had made one himself which answered quite as well.

At the Crystal Palace in London, five years later, Edison gave the Princess of Wales a bouquet of flowers containing three hundred and

fifty blooms of metal and coloured glass, so arranged that, by turning a hidden switch, a tiny electric lamp would glow in the heart of each flower.

Since that first imperfect lamp was made by Edison and Batchelor, many men's minds and hands have worked at the improvement of the incandescent lamp, and, as a result, we have the beautiful light which always delights us, and which is certainly in many ways better than any other. But it is to Edison that we owe the first step of real progress; and, had it not been for his wonderful genius and still more wonderful perseverance, the problem might not even yet have been solved.

There is only space to mention briefly the kinetoscope—or bioscope, as it is sometimes more easily called. Every one knows it, for in every town and village there have been exhibitions of "living pictures." This, too, we owe to Edison. Looking at the old-fashioned "wheel-of-fortune," he saw that, if a large number of photographs of the same moving thing could be taken in a very short time, and if these pictures could be shown on a screen in just as short a time, and in regular order, the picture would seem to be alive, and the incidents would appear to happen just as they had in reality.

Following out this idea, he invented an apparatus by means of which photographs could be taken one after another, at a tremendous rate, and yet quite distinct, on a long roll of a specially-prepared film. Thus he produced his pictures.

He then made another apparatus, which would pass this film at exactly the same rate over the object-glass of a strong magic-lantern,—and the thing was done.

You all know what wonderful scenes can be shown by this means — the landscape from a moving train, the galloping of a troop of horse, the departure of an emigrant ship, and many other pictures.

This wonderful inventor, only a few of whose discoveries have been mentioned, is now over sixty years of age; but he has not yet retired from active work, though at present he works only fourteen or fifteen hours a day.

Lately he astonished the world by stating that he had solved one of the most difficult problems of electricity—the making of a light storage battery. A storage battery is a vessel in which a certain amount of electricity can be stored, and used gradually by a motor.

If a man could take his motor-car or airship to the power station, and there take into his storage battery enough electricity to serve him for many

miles, he would be as free as a cyclist, for he would carry his own power with him—a better power in every way than petrol or coal.

The only storage batteries yet invented are of such great weight that they would not do for either motor-cars or airships; but, when Edison's storage battery is put on the market, we shall see astonishing changes. There will be no more overhead tramway wires, no more live rails, no more petrol fumes; and it is possible that an end will be put to the steam-engine.

When we reflect that, at the present time, two hundred and fifty thousand people are engaged in industries brought about by Edison's inventions—when we think of the many departments of human life in which those inventions are used, we may well call him one of the greatest wonder-workers the world has ever seen—a wonder-worker, too, whose genius has always been employed for the benefit and progress of mankind.

VII.—Guglielmo Marconi.

It is said that on the morning following the death of General Gordon at Khartoum the natives in the bazaars of Cairo, a thousand miles away, knew of it and spoke of it to each other. How the news reached them we cannot tell; we do know, however, quite certainly, that neither by telegraph nor messenger—the latter, of course, was entirely out of the question—had any word come to them.

During the Indian Mutiny, our generals knew that the natives had some wonderful way of sending messages from point to point over long distances; but, though they tried hard and often to find out how these messages were sent, they were never able to do so.

In the Andaman Islands, long before the days of telegraphs, the Governor's servants used to tell him of things that had happened in the islands, some time before the steamer bringing the news had entered the harbour.

Many instances might be given of this strange power of the peoples of the East to send

messages from mind to mind; but to no European has the secret been revealed.

You have no doubt often enjoyed yourself in watching the efforts of another person to solve a puzzle already known to you. The thing is so simple to you that you are amazed he cannot see it; and you laugh heartily at the trouble he takes to do exactly the wrong thing, and thus land himself in a more hopeless muddle than ever.

It may be in this way that the Eastern native watches our clumsy attempts to find out his secret, and it may be that he has in consequence rather a low idea of our brain-power; but, though we cannot send thoughts directly from mind to mind, we can, by using special instruments, send in a moment of time messages to persons thousands of miles away without needing telegraph wires or cables.

These messages, moreover, are perfectly clear and distinct, and sent letter by letter and word by word.

The man to whom above all others we owe this, the marvel of our age, is Guglielmo Marconi, born in Italy in 1875, the son of an Italian father and a British mother.

Methods of sending messages without wires were known and used long ages before the birth of Marconi; but they were very imperfect, and neither swift nor certain.

We are told by Polybius, who wrote about the conquest of the world by the Romans, of a way in which the people, shut up in a city by an army, could talk to their friends outside.

At night-time, a number of blazing torches were placed upon the walls in such positions as to show different letters, and the message was slowly spelled out.

The Gauls, the tribes living at the time of the Roman Empire between the Rhine and the Atlantic, had yet another way of sending messages. A man with a loud voice would go to the top of a high hill, and there would shout his message, waiting until he heard an answering call from the next hill.

From the next hill the message would be shouted again; and so, from hill to hill, the call to arms or to council would go, till the whole country was roused.

Such a method could be used only where the surrounding silence made it possible for the call to be heard—nowadays it might not answer so well. Possibly, too, our voices have lost in carrying power.

In reading of the English struggle against the Spaniards in Queen Elizabeth's reign, we come across another means of signalling, specially suited to a country with a number of hills of moderate height. Beacon-fires flaring

on every hill warned the English that their enemies were coming up the Channel, and called out the strength of England to oppose the Spaniard.

A method of this kind was far inferior to that used by the Greeks of whom Polybius speaks, or to that used by the Gauls, and certainly much poorer than that formerly in common use amongst the Red Indians. Their plan was very clever, and was well suited for a country of boundless plains.

A clear fire was made with the driest sticks obtainable. Then a handful of green twigs was thrown on, causing a long thin column of smoke to ascend into the air for a minute or two. By repeating this a certain number of times, the Indians could send a message to their friends at a distance, possibly on the farther side of a hostile village or band.

Coming back to more recent times, the early years of last century saw a method of signalling in very general use nearly all over Europe. This was the semaphore. In this system, a tall post or pillar carries two arms or blades like those used on railways. By placing the arms in certain positions, different letters and numbers were indicated, and long messages were sent from one to the other, at about the rate of three words a minute.

Lines of posts or towers carrying these semaphores stretched across the continent—one line, that from the frontier of Prussia to St. Petersburg, being twelve hundred miles long.

At a distance of more than eight miles the signals could not be read easily, even with the aid of a telescope; and mist or rain made the sending of messages impossible.

Semaphore signals are still in use in both army and navy, a man acting as the tower, and his arms or a pair of flags acting as the semaphore blades.

Another method in general use in the army is the heliograph. In this instrument a small circular mirror is made to flash the reflection of the sun's rays in a certain direction, and in a manner corresponding to the Morse code of dots and dashes; and, as long as the sun is shining, and nothing comes between the heliograph and the officer to whom the message is being flashed, it works well.

Most of our warships and many of our forts have what are called searchlights; that is to say, electric lights so surrounded by reflectors and lenses that they can throw a beam of dazzling light to an enormous distance. By using a shutter, this beam can be made to shine out in long and short flashes, spelling words by the Morse code.

Many of these plans are still in use, together with that of flag-signalling, used by ships speaking with each other and with shore stations —you will remember the famous flag-signal, "England expects every man to do his duty," shown by Nelson's ship, as she moved to the attack at Trafalgar—but, for sending messages over long distances, they have given place to the telegraph and the telephone.

The telegraph and the telephone, wonderful though they are, have one serious drawback—between the two stations must be fixed the long wire. This is an expensive item, and in time of war it is open to the enemy to cut the wire, and so to prevent communication, or, a still more dangerous thing, to tap it for their own information.

From the days of Wheatstone and Morse, men have tried to devise plans of doing without these costly conductors, but with little success till Marconi found the way.

The Abbé Moigno, in 1840, announced as a great wonder that Wheatstone had found out a method of sending messages from England to France.

"I have touched with my hands," he said, "the conducting wire which, buried in the depths of the ocean, will unite the shores of England with the shores of France."

But many discoveries had to be made, and many deep thinkers had to work hard, before submarine cables could be laid from country to country and continent to continent. Amongst those whose work should never be forgotten, was Lord Kelvin, who conquered many difficulties with regard to deep-sea cables.

The laying of these cables is a most costly business. The cable itself costs something like one hundred and fifty pounds per mile, and large sums are needed for its laying and for its upkeep; but the need of such a means of communication, and the certainty of a rich return for the money spent, induced people to attempt the task.

The use of steamships instead of sailing-ships had lessened the time between the sending of a letter, say, to America, and the receipt of an answer; but the rapid growth of America, and the increase of trade between that continent and Europe, made people on both sides chafe against the delay.

The first Atlantic cable was ready in 1857, and, after two failures, owing to the breaking of the cable, it was laid along the floor of the Atlantic, from Valentia Island in Ireland to Heart's Content in Newfoundland. For some time messages were sent to and from Ireland and America—and then something went wrong, and the current ceased to pass.

During the next seven years cables were laid across the Red Sea, the Mediterranean, and the Persian Gulf; but, people with money were chary of risking it in any further attempt to connect the two sides of the Atlantic..

However, in 1865, a start was made with a stronger cable; but, after more than twelve hundred miles had been paid out, the cable broke and sank to the bottom.

The largest vessel then afloat, the *Great Eastern*, had been employed as the cable-ship. She was an unwieldy monster—a screw and paddle steamer of nearly nineteen thousand tons, and had been a failure as a cargo or passenger ship, partly because she was built before there were docks or quays or harbour channels large enough for her. Big as she was, she is far exceeded in length and tonnage by the two mighty Cunarders, about which you have already read.

But she was the very thing for a cable-ship; and, though the first cable was lost, she carried out a second, which was safely landed at Heart's Content, thus linking up Europe and America securely.

Many other cables have since been laid across the oceans and seas of the world; and little of real importance can happen in any quarter of

the globe, about which the news is not in a few hours printed in the daily papers.

Still, it is a costly business; the expense of laying the cable is only the beginning. The shore-ends, where the cable chafes upon the rocky sea-bottom, need constant attention and frequent repairs; a repair-ship is kept in almost constant work, and there is a considerable leakage of current.

All this expense makes the charge per word for cablegrams very high; and yet, so important is it to many people to have the latest news at the earliest time, that millions of cablegrams are sent every year.

It is said that nearly one hundred millions of pounds are invested in submarine cables, in different parts of the world.

Wonderful though it is, however, to send messages from continent to continent along a submarine cable, it is still more wonderful to send them without using any cables at all. Yet this is what Marconi's invention enables us to do.

In order to perform this marvel we need an oscillator, a coherer, a tapper, and an aerial wire, together with electric batteries.

These words will not have much meaning to you yet, so perhaps a little explanation may not be out of place. You will perhaps be surprised

to hear that, though Marconi made many improvements in all these things, he invented none of them. He was, however, the first to employ them in such a way that by their means distinct messages could be sent and received, so that he was most certainly the inventor of wireless telegraphy as we know it.

Before you can understand the use of these things, you must know something of the discoveries which led up to them.

Have you ever wondered how the light of the sun travels to our earth? People wondered about it, but could not explain it for thousands of years, till Huyghens, a Dutchman who lived two hundred and fifty years ago, and who invented the pendulum clock, gave his opinion that all space is filled with a substance so thin, so light, and so entirely without weight, that, only by considering what it does, can we prove that it is there at all.

This "ether," said Huyghens, must be made up of particles so tiny that they can penetrate the substance even of solid gold. When all the air has been pumped out of a vessel, he said, the ether is there—it can get in and out through the solid sides of the vessel, though neither air nor water can pass.

According to him, light is simply a wave-motion in this ether, just as sound is a

wave-motion in air. The sun, or other glowing body, sets up wave-motion in the surrounding ether, and this wave-motion is passed swiftly on till our eyes are reached.

James Clerk Maxwell, one of Scotland's clever men, went, in 1864, a step further than Huyghens, by proving that electricity and magnetism are also like light—conveyed by wave-motion in the ether.

Some years after this Lord Kelvin showed how these electric waves could be set up in the ether; and, in 1888, Professor Hertz, a German, invented an apparatus for setting up these waves, and another which would catch or detect them. The first he called an "oscillator," and the second a "detector."

The oscillator consisted of two large metal plates placed parallel to each other, having fixed to the centre of each a short, stiff wire ending in a small metal ball. The plates were so placed that only a short space separated the balls. To the stiff wires, close behind the balls, were fastened the ends of the secondary of an induction coil—you will know what an induction coil is in a moment—the primary of which was acted upon by an electric battery.

Professor Faraday had discovered that, if a short coil of stout wire be surrounded by a very long coil of fine wire, a current of electricity

sent though the inner coil, or primary, will cause electric sparks to pass between the ends of the long coil surrounding it—the outer coil being called the secondary of the induction coil. It is called an induction coil, because the currents passing through the inner coil induce currents in the outer coil.

Now, in Hertz's oscillator, if a current was passed through the inner, the outer coil, the ends of which were fastened to the stiff wires just behind the little balls, came into action at once, and a big spark passed between the balls. This was caused by the positive electricity from one ball jumping to meet the negative from the other ball.

Passing each other, they rushed along the short wires to the plates, which thus became charged with opposite kinds of electricity, and hastened to exchange. This caused another spark between the balls, and another rush back again of the opposite kinds of electricity, and so the movement went on till the force was all spent. You see now why this instrument is called an "oscillator."

You have all thrown stones into ponds, and know that, if you throw a big one into the middle of the pond, big waves spread out till they reach the shore. Now, the electric spark between the balls acts upon the ether just as a

stone acts upon the water in a pond—it sets up waves spreading in all directions. If the current is kept passing for a long time, and there is a long train of sparks, there is a long train of ether waves; if the passage of the current is short, causing a short train of sparks, then there is a short train of waves.

Suppose now that a long train of waves stands for a dash, and a short train of waves stands for a dot, you could spell out words which any telegraph operator could read. But you would have to possess some instrument which could detect these trains of waves.

Hertz had invented a "detector," but it was useful only for short distances. Something better was needed; and this was invented in 1891 by Professor Branly of Paris.

He had found that if a little glass tube, filled with metal filings, were placed in the circuit of an electric battery, no current would pass; but if waves in the ether—Hertzian waves, as they are always called—were set up at a distance, the metal filings in the tube seemed to stick or cohere together, and the current from the battery passed through.

Even after the movement had ceased, the filings continued to cohere and the current to pass; but, as soon as he tapped the tube, ever

so slightly,' the filings fell apart and the current ceased.

Marconi fixed this sort of detector or coherer to his receiving apparatus, and found it was able to detect movements at a much greater distance than Hertz's detector. Still, it was far from perfect; for, unless the man who was trying to receive the message kept tapping the tube all the time, he could not tell whether the train of waves was long or short.

In 1894, Sir Oliver Lodge, the principal of Birmingham University, invented a "tapper" which would work by itself. As long as the Hertzian waves pass across the tube a tiny hammer keeps tapping it, giving the last little tap just as the waves cease, and so shaking the filings apart and stopping the current.

With this tapper fixed to his coherer or detector, Marconi was able to send and receive messages. Then he made a better coherer than Branly's, though on the same principle, and so got one step nearer to his aim.

His receiving instrument was now fairly satisfactory; but that for sending was by no means so good. Messages would travel but a very short distance.

During the next year the final discovery was made. A Russian named Popoff found that

he could detect the waves by joining a Branly coherer to a lightning conductor.

This gave Marconi just the idea he wanted. Instead of the upper plate of his oscillator, he hung a long wire from the top of a pole; and instead of the lower plate he had a wire leading into the earth. Above and below the narrow gap between these two wires, he now placed the two metal balls, connecting the induction coil as before.

Marconi soon found that the higher were his poles, and therefore the longer his wires, the greater was the distance to which messages could be sent.

The invention was now in working order, so he lost no time in protecting his interest in it. He was still only twenty years of age.

The next step was to get people to believe in his invention, and to put it to the test; and he resolved that England was the best country for his purpose.

After several small tests a much more difficult task was set him—to send signals from Penarth on the coast of Wales, to the island of Flatholm in the Bristol Channel.

For three days he tried to get signals across the three miles of water, but without success; and many people were beginning to lose all faith, when it struck him that perhaps the aerial

wire of the transmitting instrument was not long enough. Carrying it to the foot of a cliff, he attached the wire to the top of a pole on the brow of the rock, and at once had a complete success.

Next day he sent a message nine miles across the Bristol Channel to Brean Down; and later in the year made some successful trials on Salisbury Plain.

People were now beginning to believe there was something in the new system, and were willing to buy shares in the "Marconi Wireless Telegraph Company."

A station was set up in the Isle of Wight at Alum Bay, and regular communication was kept up with Poole, eighteen miles distant.

Lloyd's, the London company which sends shipping news all over the world, saw what a good thing it would be for them if passing ships could signal to their look-out stations, even in time of fog or during the night; and they asked Marconi to test his system between Rathlin Island and Ballycastle.

Before they had quite made up their minds, a splendid chance occurred of showing what the system could do in enabling signals to be passed between ship and shore.

At the Kingstown Regatta, Marconi had a swift steamer, the *Flying Huntress*, fitted up with his

instruments, a land-station being arranged at the back of the harbour-master's house, the pole carrying the wire being forty feet in height.

The steamer followed the yachts as they raced, sending messages to shore every ten or fifteen minutes. Hundreds of messages were thus sent, every one being correctly received.

This proved amongst other things that the movement of the steamer had no effect upon the clearness of the signals; so that it might be possible for two moving steamers to speak with each other at a distance.

When the Prince of Wales, our present king, injured his knee on board the royal yacht *Osborne*, which was then in Cowes Bay, Marconi sent ashore to Queen Victoria about one hundred and fifty messages during the sixteen days of the Prince's illness.

This success caused Marconi and his invention to be widely known. Even before this time, however, the Italian Government had placed his instruments upon some of their warships.

On March 27, 1899, he succeeded in sending messages between Dover in England and Boulogne in France; and his system was used by the French Government.

Later in this same year it was tested in our own navy with satisfactory results—only some people said that since the waves went out in

every direction, any instrument could pick up the messages.

Marconi, however, had foreseen this, and met it by so "tuning" his instruments that only a receiver properly "tuned" could take the message.

The Parliament of Newfoundland, our oldest American colony, made inquiry into the system, one of Marconi's assistants carrying out a number of tests before the members; and Marconi himself went out to New York to report, as he had done at Kingstown, a great yacht race. This he did with complete success, also carrying out some tests for the United States navy.

Shortly after this the war with the Boers broke out in South Africa, and Marconi was called upon to equip sets of his instruments for service in the field.

When the steamer upon which he was a passenger, the *St. Paul*, was sixty miles from England, her instruments picked up a signal from Alum Bay; and twenty miles further on the question was received: "Is that you, *St. Paul?*" A little later came: "Hurrah, welcome home, where are you?"

By this time the system had been adopted by the British and the Italian navy; the light-houses and light-ships around the shores of

Britain had been fitted with instruments; the British Lloyd's Company had fitted up many of its stations; communication had been established by its means between Dover and Boulogne, Harwich and Chelmsford, Salisbury and Bath, and Alum Bay and the Lizard. Besides all this, the system was showing itself of service in the war in South Africa.

In the year 1900, after having made many improvements, and having found out a way of increasing the power of his transmitter, Marconi tried a yet bolder experiment. At Poldhu, in Cornwall, he built a new station, and fitted it with the finest and most powerful instruments he could procure. There were no fewer than twenty masts with aerial wires, and electric power enough to have kept more than three hundred lamps burning.

Towards the end of 1901 all was ready, and Marconi, with two of his best assistants, crossed to St. John's, Newfoundland. Here they set up their instruments on Signal Hill, intending to hold up their wire by means of a kite.

The wind sweeping the kite away, they tried a balloon; but this followed the kite; but the next morning a second kite held at the height of four hundred feet.

There was nothing now to do but to wait till the signal upon which they had agreed

should be sent from Poldhu. This was to be the letter "S" in the Morse code.

It was a cold, wet day, with both fog and gusty wind; and, as the time went on and no signal came, the minds of the three men became almost as gloomy as the day.

Marconi's face showed no change; but those of his assistants were filled with excitement, when at last the signal came—three sharp clicks, over and over again, the letter "S" according to the Morse code. Communication had been established between England and America.

Much yet remained to be done, however, before messages could be sent from continent to continent.

During the years that have passed since that November day, the system has been more and more improved; and lately it was announced that the Marconi Company would send messages across the Atlantic at so much per word—much cheaper than by cable.

Another remarkable development is the receipt of news by ocean liners on their voyage, both from either shore and from other steamers. The great liners of the Cunard Company have a daily paper called the *Cunard Daily Bulletin*, in which are printed all the latest news and messages from passing steamers. Heads of business-houses in England and America, who

may be crossing the Atlantic, may receive daily reports from their assistants, and can send answers by return Marconigram.

Many other systems of wireless telegraphy have sprung up, some of which are widely used. Marconi's, however, is judged to be the best; it is the only one which has sent messages across the Atlantic; and it is developing at a greater pace than any of its rivals. For the marvellous means of communication which he has given to the world, Marconi deserves the gratitude and warm regard of mankind.

NOTES.

PAGE

7. **Microscope**: An instrument formed by an arrangement of lenses at each end of a tube. The tube is so made that its length can be altered. The purpose of the instrument is to increase the size of objects examined through it, in order that minute differences may be discovered. (Greek *mikros*, little, and *skopein*, to look.)

12. **St Denis**: The patron saint of France, just as St. George is of England and St. Andrew of Scotland.

39. **Hydrophobia**: A terrible disease which attacks persons who have been bitten by a mad dog. If for nothing else than his work in conquering this disease the name of Pasteur ought to be held in honour. Dread of water is a symptom of the trouble. (Greek *Hydor*, water, and *phobos*, fear.)

60. **Parapet**: A wall raised breast high as a protection against some danger.

Cultivable: Able to be cultivated.

65. **Breakwater**: A breakwater is a strongly built wall running from the land, out to sea, for the purpose of *breaking* the force with which the *water* dashes inshore—hence its name.

PAGE

67. **Fellahs**: An Egyptian peasant is called a fellah. The plural of the word is fellaheen, but the ordinary English plural form—the word having "s" added to it—is frequently used.

68. **Pontoon**: A bridge of flat boats.

71. **Disastrous**: Having a sad ending. (Latin *dis*, apart, in a bad sense, and *astrum*, a star.)

79. **Hydrogen**: The name of the lightest gas known. A volume of hydrogen is the standard by which all other gases are compared as regards their weight.

79. **Propeller**: Blades fixed at the end of the screw of a steamship in such a way that, as the screw forces them round, they convey a forward motion to the vessel.

87. **Dirigible**: that may be directed or steered.

95. **Aerial Cruisers**: War vessels which, instead of sailing on the sea, will fly through the air.

98. **Turbines**: In this form of steam-engine, the steam is used to drive the propeller-shaft, without having to pass through cylinders or use pistons.